Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

The WEAN

ENGINEERING CO., Inc. WARREN, OHIO

Subsidiary Company

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CLEVELAND, OHIO

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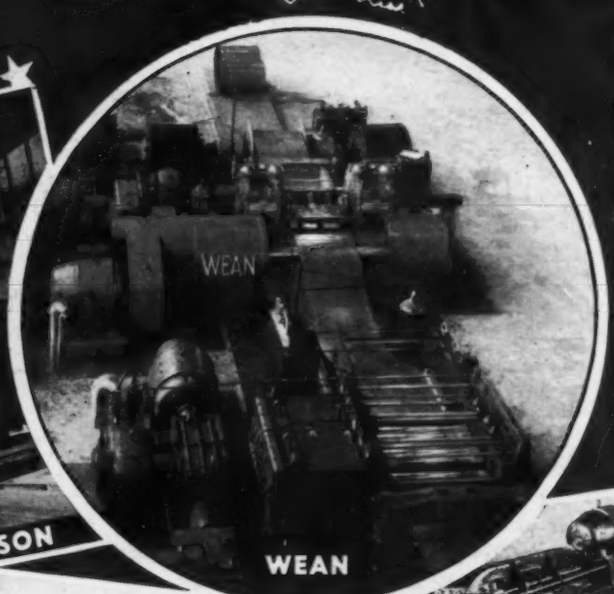

WEAN

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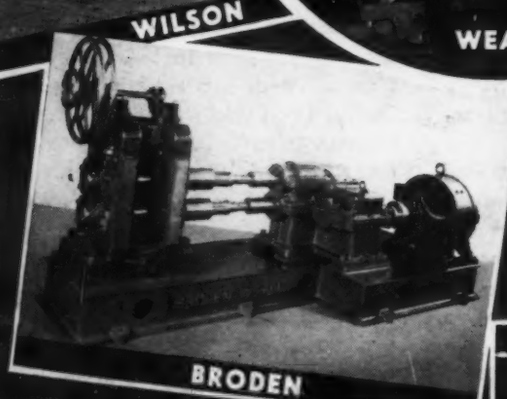
BRODEN

SPECIALISTS IN
SHEET, TIN & STRIP
MILL EQUIPMENT

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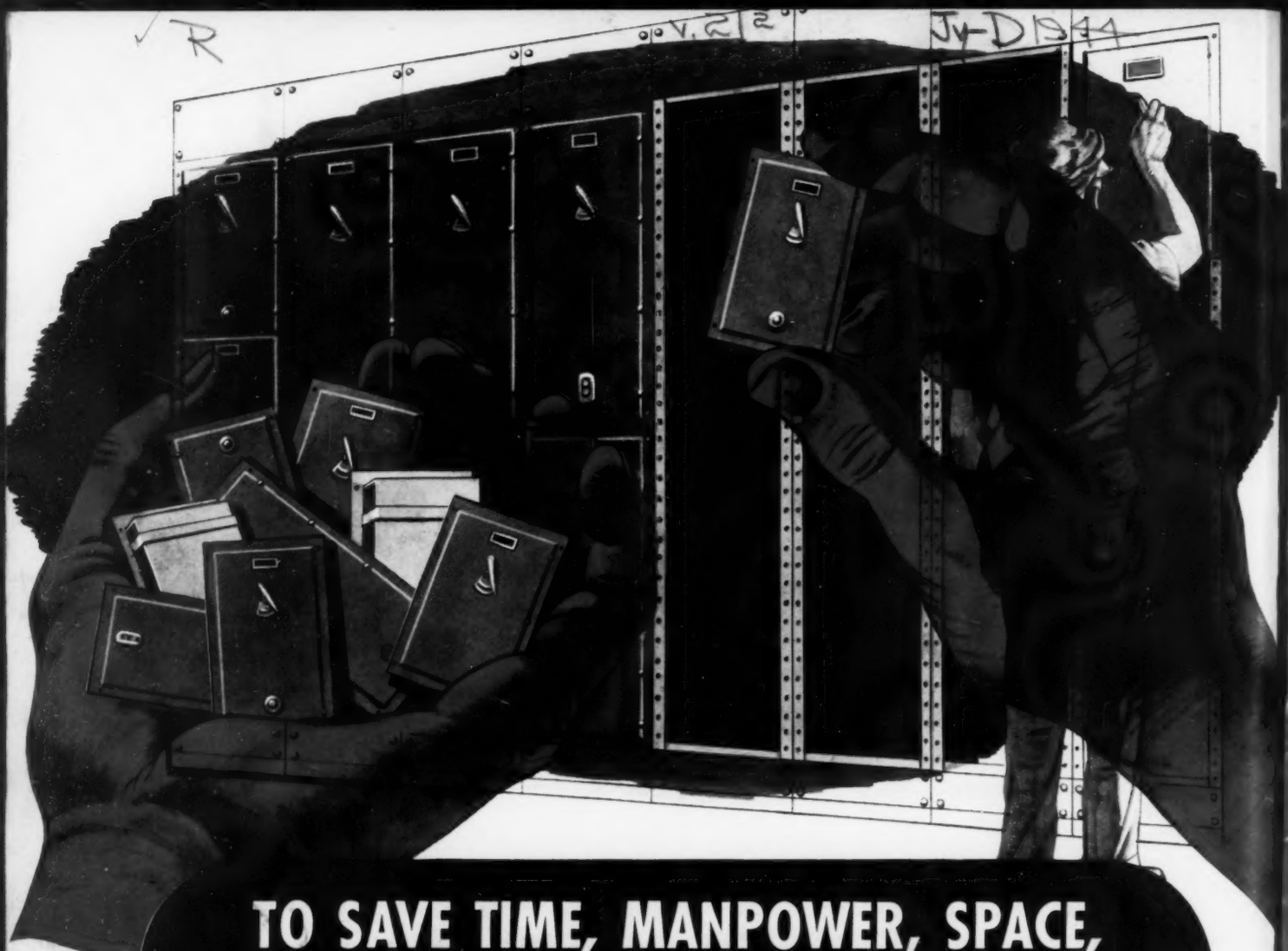
HALLDEN



TO SAVE TIME, MANPOWER, SPACE, *TODAY and TOMORROW*...USE UNITROL

The Filing Cabinet Idea applied to motor control

1. Skeleton Starter

Unitrol is built up in much the same way as the familiar filing cabinet system.

The skeleton starter or switch (see photo No. 1 at left) is fitted into a frame with a door in front (see photo No. 2 below).

2. Unitrol Door Frame

This Unitrol "unit" is fitted into a section (see photo No. 3) and sections are placed side by side, as many as you want as in sketch at bottom.

3. Unitrol Section

Like your filing cabinet system, the contents of each "drawer" are easily changed or placed in other "drawers". Sections can be rearranged, moved elsewhere, or new ones added. Unitrol is the flexible, versatile system of housing motor control for all time, ready at any time to meet all needs. You should investigate it today.

4. Unitrol Control Center

You can begin any time to put in UNITROL, the *better* way to house, install and systematize motor control. If you are buying control for new machines, ask for it in Unitrol. Then you won't have to spend time and manpower on wall or floor preparation. Unitrol can be placed anywhere in the plant ready for work the moment electrical connections are made.

If you are moving equipment around because of a production changeover, make it an opportunity to house the control in Unitrol. Then your inspection and service men can accomplish more because the control will be grouped in a compact Unitrol "center", convenient of access, easy to service, hard to overlook. Tremendous space savings result because Unitrol can accommodate 2 or 3 times as much control in equivalent floor space.

Unitrol is the modern method of housing control, ready made, ready for use, yet built to individual need from unitized, sectionalized members that you can add to, subtract from or rearrange with complete freedom. Many industrials, wanting to be *first* with the *right* answer for today *and* tomorrow, are swinging to Unitrol. For the facts behind the swing, write today for the big free Unitrol book. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto, Ont.

CUTLER-HAMMER
UNITROL
C-H

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Engineering Excellence Finds its Greatest Reward in the Respect and Confidence of those it Serves

THERE'S ALWAYS SOMETHING *New* AT AETNA-STANDARD ★

EXPANDING MANDREL TYPE PAY-OFF REEL

..with these Two Patented Features

1 Combination of Expansion Reel and Loading Device.

2 Automatic Coil Centering Device.

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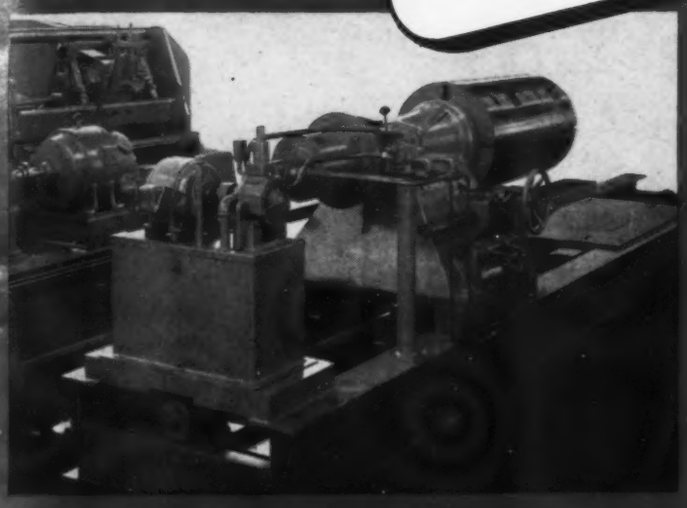
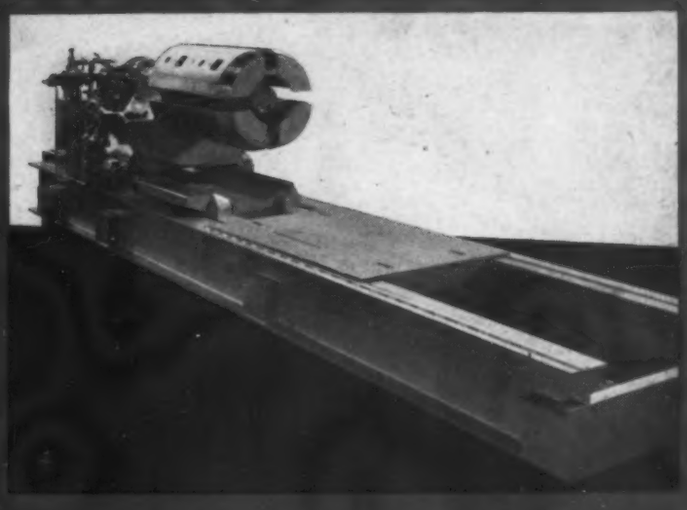
DETROIT



Aetna-Standard reel collapsed for loading.



Aetna-Standard reel expanded for operation.

Coils in any commercial widths and weights up to 30,000 pounds can be handled quickly and easily with the Aetna-Standard type reel.

The unusual head expansion of 7 inches takes care of those out-of-round coils which usually slow down production. The 4 quadrants give full support to the coil, eliminating coil breaks. Rigid expansion is maintained without use of links.

With this Aetna-Standard reel, you can have either hydraulic or mechanical lift and traverse; regenerative or hand braking for back tension; air hydraulic head expansion. Removable shoes permit handling of oversize coils. The pay-off drive is optional.

To speed up coil handling, equip your mills with Aetna-Standard reels.

The AETNA-STANDARD ENGINEERING COMPANY
YOUNGSTOWN · OHIO · U.S.A.
ARMY E NAVY

FACTS ABOUT AETNA-STANDARD

Aetna-Standard builds all types of uncoiling reels and coil boxes ... handling hot or cold-rolled, ferrous or non-ferrous strip in coils ... located ahead of processing lines.

DESIGNERS AND BUILDERS TO THE STEEL, NON-FERROUS AND CHEMICAL INDUSTRIES

ASSOCIATED COMPANIES Head, Wrightson & Company, Limited, Thornaby-On-Tees, England
John Inglis Company, Limited, Toronto, Ontario, Canada

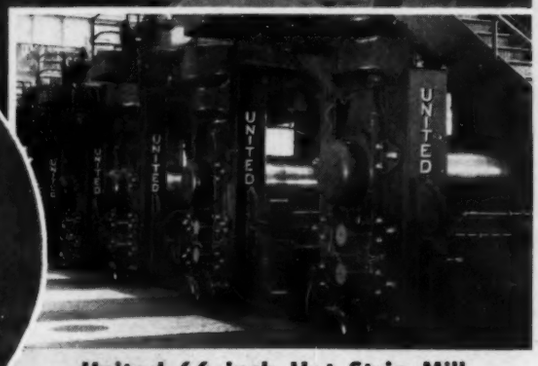
UNITED Hot Strip Mills

Designs For

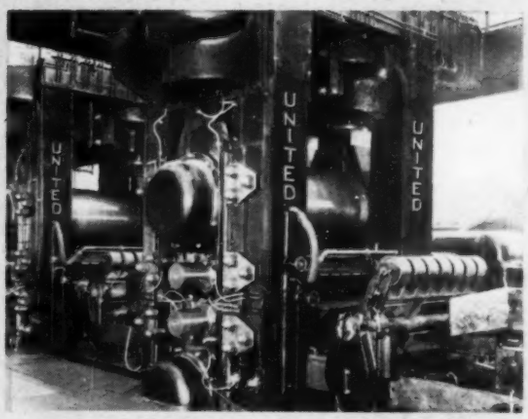
★98 inch ★66 inch

★56 inch ★43 inch

and Intermediate Sizes
Immediately Available



United 66 inch Hot Strip Mill



United 56 inch Hot Strip Mill

United 43 inch Hot Strip Mill

WE have greatly increased our Rolling Mill production facilities to meet war requirements, and very shortly we expect to be able to offer attractive deliveries on units duplicating the above HOT STRIP MILLS, or modifications of them adapted to meet your specific requirements.

Recognized pre-eminence in technical research, and more than 40 years experience in the design, construction and installation of Rolling Mills and their auxiliary equipment for leading steel manufacturers throughout the world, is evidence of UNITED'S ability to serve you.

In planning for present or postwar expansions you should consult with our engineering staff.

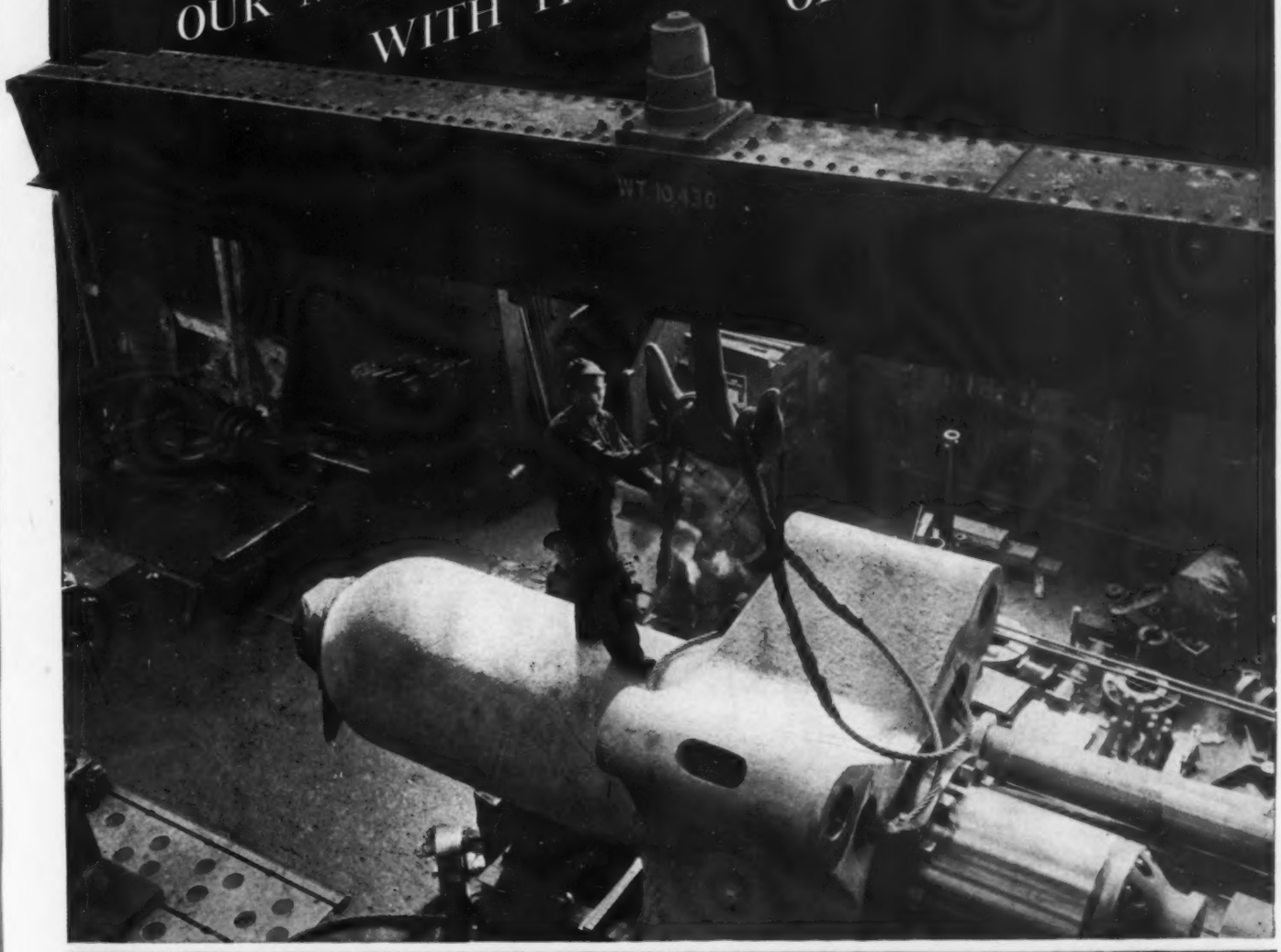
UNITED ENGINEERING AND FOUNDRY COMPANY
PITTSBURGH, PENNSYLVANIA

Plants at PITTSBURGH, VANDERGRIFT, NEW CASTLE, YOUNGSTOWN, CANTON
Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment

ASK US IF IT IS HYDRAULIC

OUR MACHINERY IS BUILT IN ACCORDANCE WITH THE SPECIFIC REQUIREMENTS OF EACH CUSTOMER



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ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
STRETCHERS · PUMPS · ACCUMULATORS

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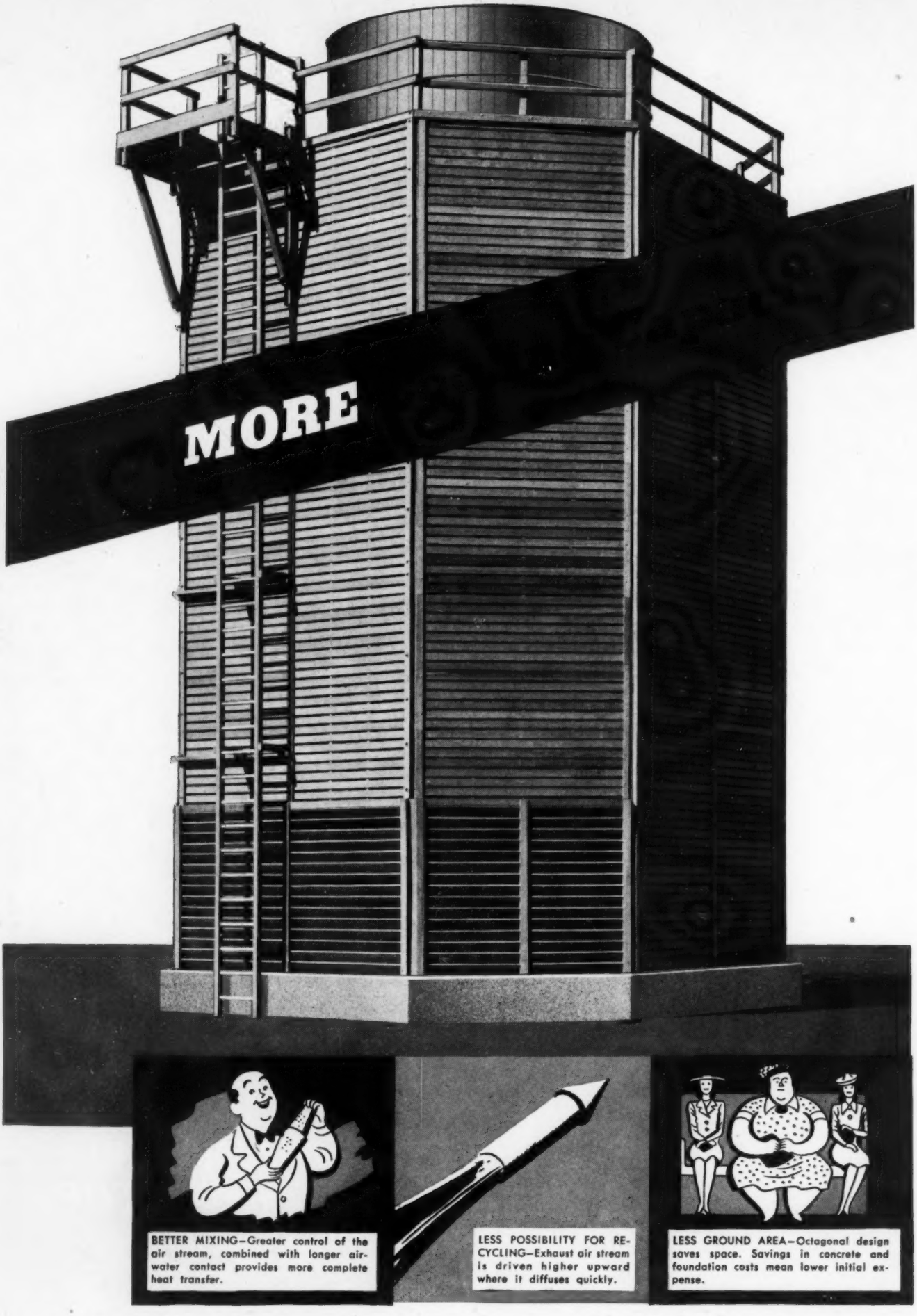

MORE
BETTER MIXING—Greater control of the air stream, combined with longer air-water contact provides more complete heat transfer.
LESS POSSIBILITY FOR RE-CYCLING—Exhaust air stream is driven higher upward where it diffuses quickly.
LESS GROUND AREA—Octagonal design saves space. Savings in concrete and foundation costs mean lower initial expense.

LESS

The new FLUOR Counter-Flow Induced Draft Cooling Tower makes obsolete all previous standards for cooling tower performance per dollar of cost. Here are just a few reasons why:

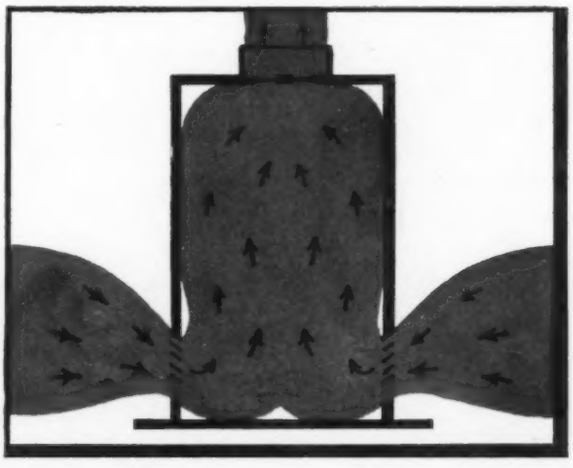
It more nearly approaches the optimum efficiency of true counter-flow heat transfer. Air and water, flowing in opposite directions, are brought together in longer and more thorough contact.

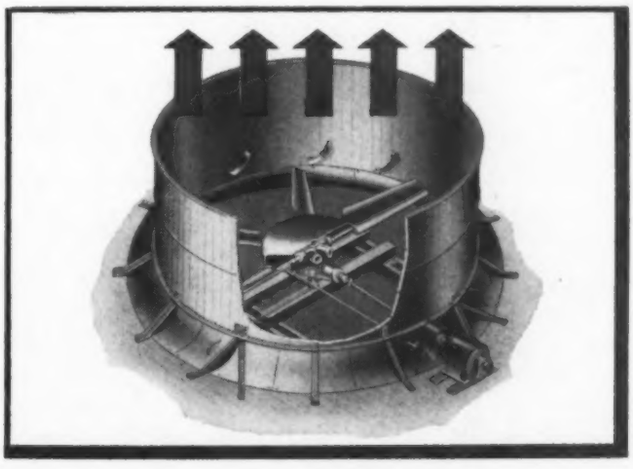
Greater distance between the point of high velocity saturated air discharge on top of the tower and the fresh air intake at the bottom of the tower minimizes recycling often found in ordinary mechanical draft cooling towers.

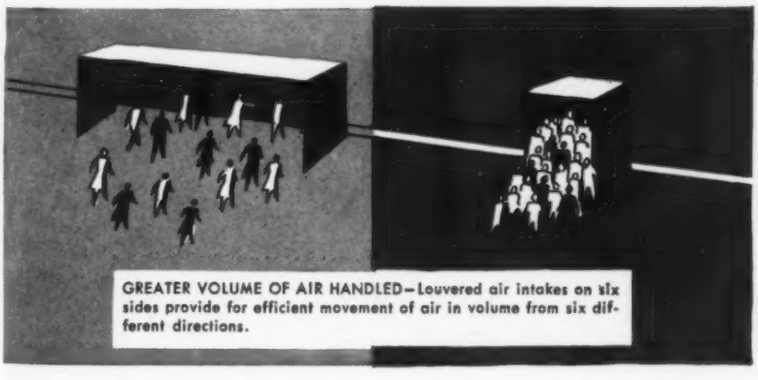
Greater heat transfer per unit of ground space reduces the number of fans and power-consuming mechanical equipment required since each cell does 40% more cooling than an identical tower 25 feet high. To saving in ground space is also added substantial reduction in the amount of concrete, reinforcing steel and other materials used in cooling tower basins.

These advantages, plus Fluor Shear-Plate Construction, complete pre-fabrication, Aerator panel exterior, and many other Fluor "firsts" make the new Fluor Counter-Flow Induced Draft Cooling Tower an important advancement in cooling tower design and performance.

All designs for FLUOR Aerator Cooling Towers and FLUOR Counter-Flow Induced Draft Cooling Towers are fully protected by U. S. Patents and Patents Pending.







GREATER VOLUME OF AIR HANDLED—Louvered air intakes on six sides provide for efficient movement of air in volume from six different directions.

SINCE 1890

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ENGINEERS · MANUFACTURERS
CONSTRUCTORS

Process Plants & Equipment for Oil, Gas & Allied Industries
THE FLUOR CORPORATION, LTD.
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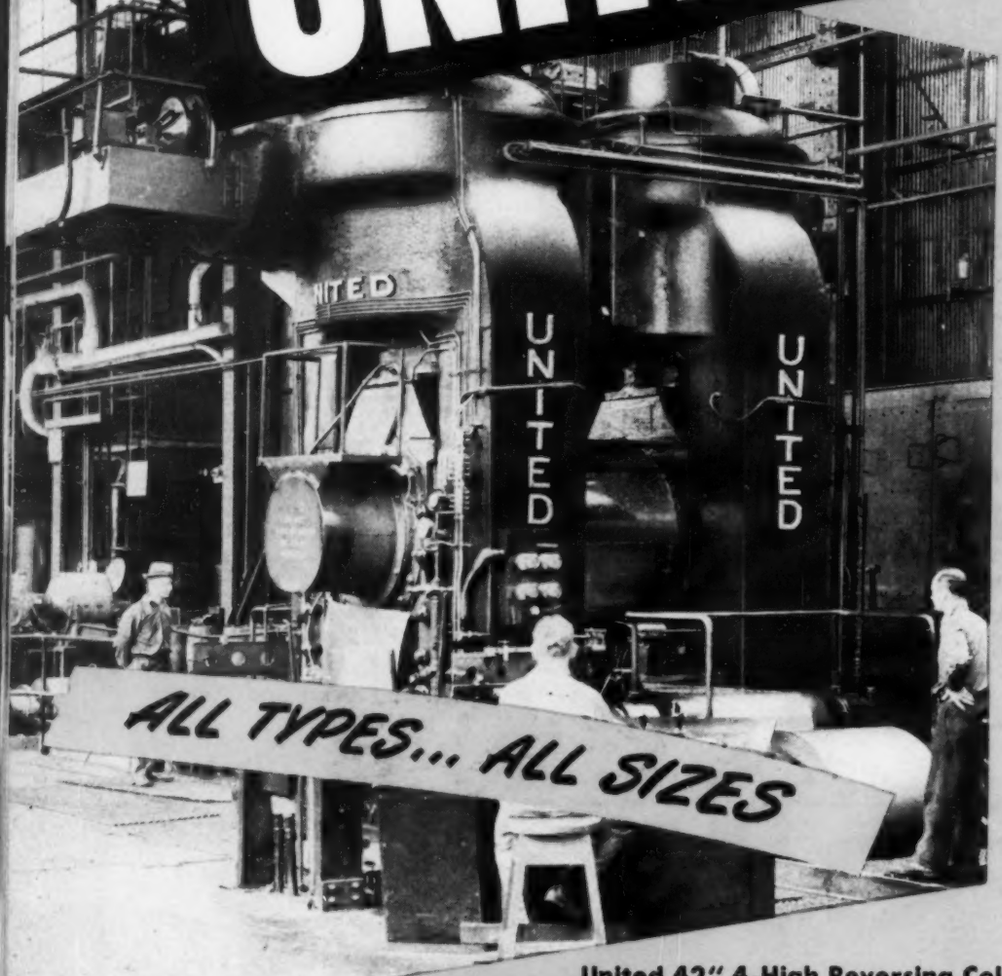
UNITED Cold Strip Mills

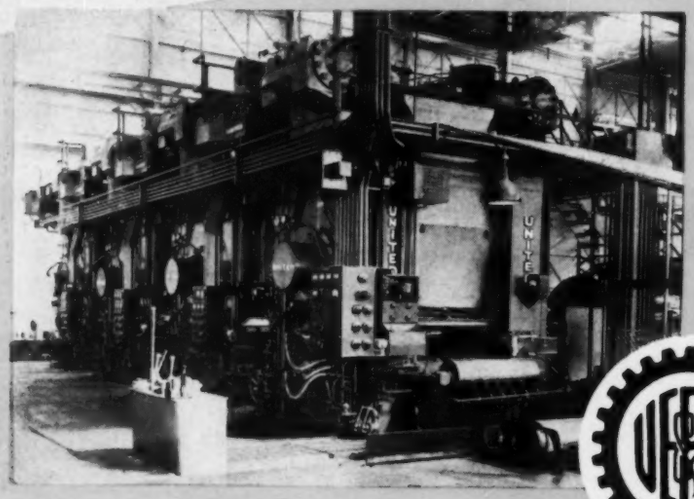


United 42" 4-High Reversing Cold Mill

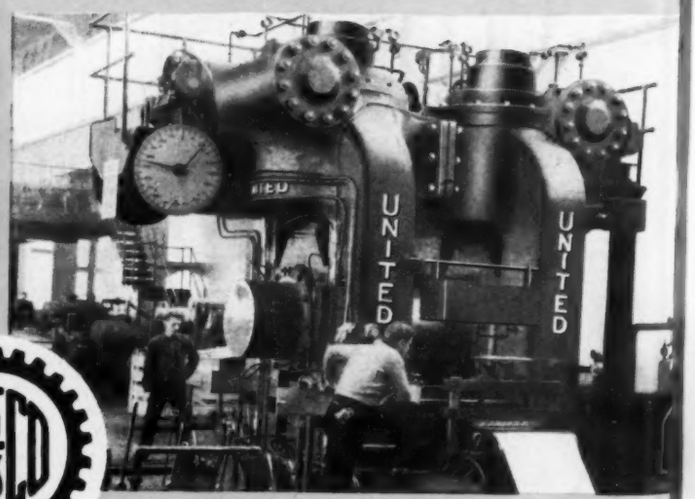
We have greatly increased our Rolling Mill production facilities to meet war requirements, and very shortly we expect to be able to offer attractive deliveries on units duplicating existing designs of all types and all sizes of COLD STRIP MILLS, or modifications of them adapted to meet your specific requirements.

Recognized pre-eminence in technical research, and more than 40 years experience in the design, construction and installation of Rolling Mills and their auxiliary equipment for leading steel manufacturers throughout the world, is evidence of UNITED'S ability to serve you.

In planning for present or post-war expansions, you should consult with our engineering staff.



United 54" 4-High, 4-Stand Tandem Cold Mill



United 28" 4-High Reversing Cold Mill

UNITED ENGINEERING AND FOUNDRY COMPANY

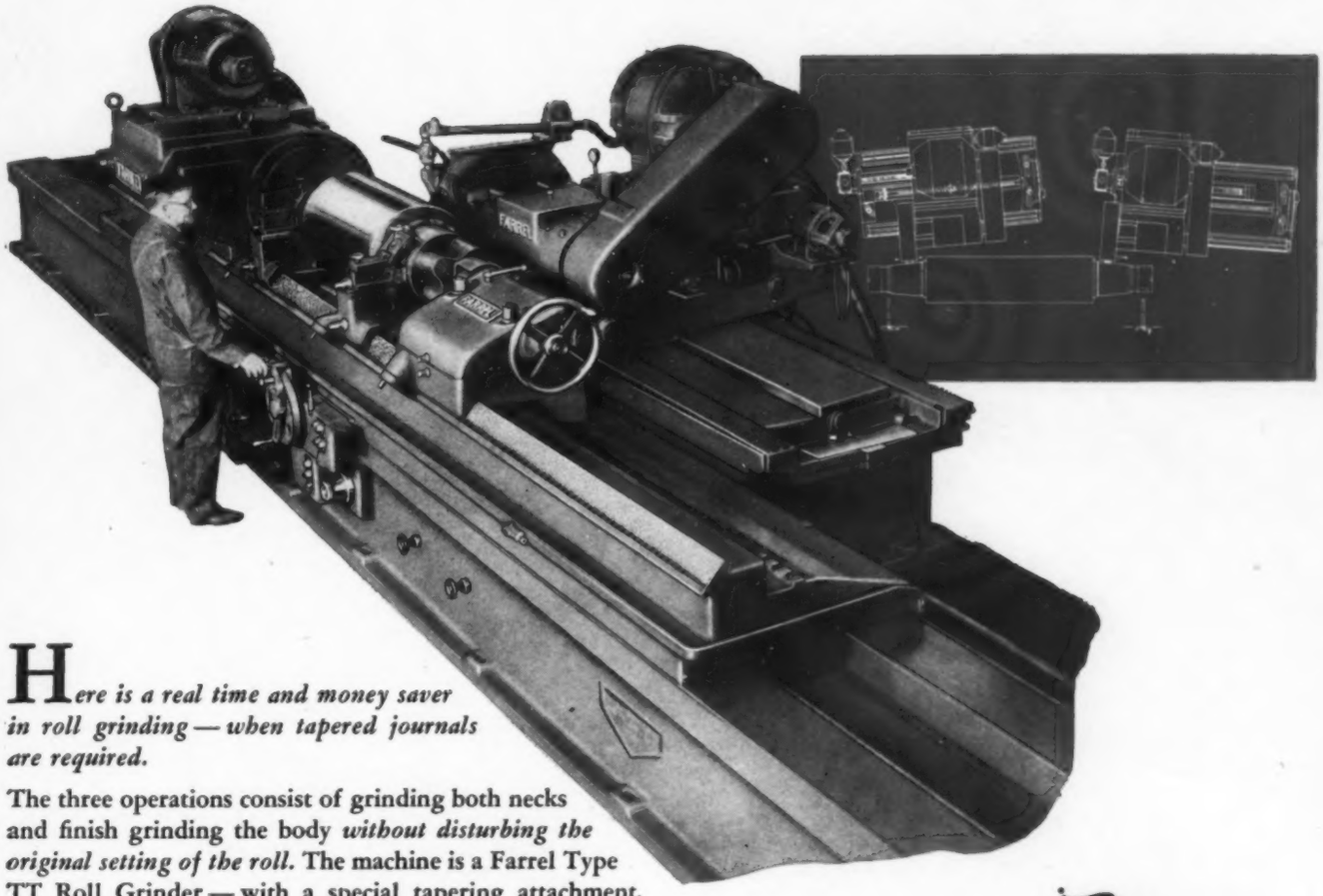
PITTSBURGH, PENNSYLVANIA

Plants at PITTSBURGH, VANDERGRIFT, NEW CASTLE, YOUNGSTOWN, CANTON

DAVY AND UNITED ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND
DOMINION ENGINEERING WORKS, LTD., MONTREAL, P. Q. CANADA

** The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment*

Three ROLL GRINDING OPERATIONS WITH ONLY *One* SETTING OF THE ROLL



Here is a real time and money saver in roll grinding — when tapered journals are required.

The three operations consist of grinding both necks and finish grinding the body *without disturbing the original setting of the roll.* The machine is a Farrel Type TT Roll Grinder — with a special tapering attachment.

The diagram shows how the tapers are ground. It is merely necessary to offset the swivel base carrying the grinding wheel in one direction for one neck and in the opposite direction for the other. A simple adjustment gives the exact amount of taper without requiring adjustment of the footstock or other units of the machine. Any commercial taper can be accurately reproduced.

Of the traveling work table type, the Farrel TT Roll Grinder becomes, in effect, a wheel-moving machine when the tapering attachment is in operation, the work table remaining stationary and locked in position.

But this is only one of the many features of the Farrel Type TT Roll Grinder. For complete description, write for Bulletin No. 113. Your free copy will be sent on request.

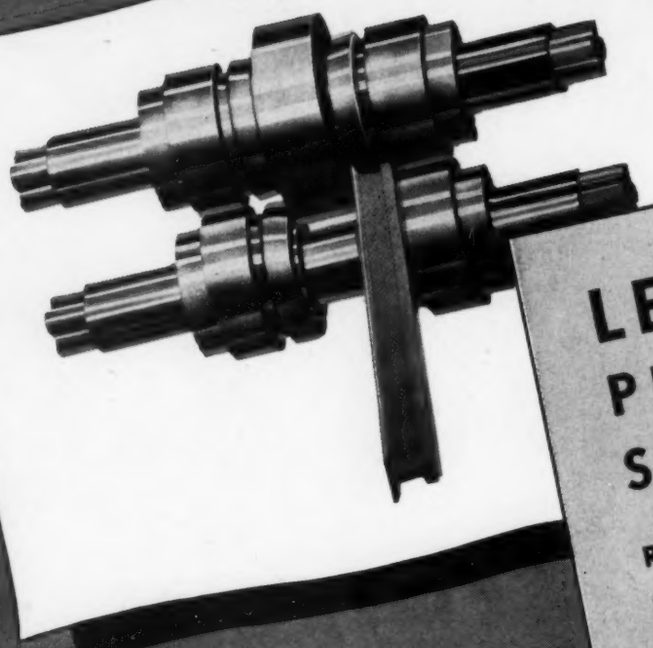
FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles

FARREL ROLLING MILL MACHINERY

- Rolls
- Rolling Mills
- Rod Mill Tables and Manipulating Equipment
- Universal Mill Spindles
- Rod Coilers
- Gears
- Mill Pinions
- Pinion Stands
- Gear Drives of any Capacity
- Flexible Couplings
- Roll Grinding Machines
- Roll Calipers
- Lead Presses for Pipe or Rod

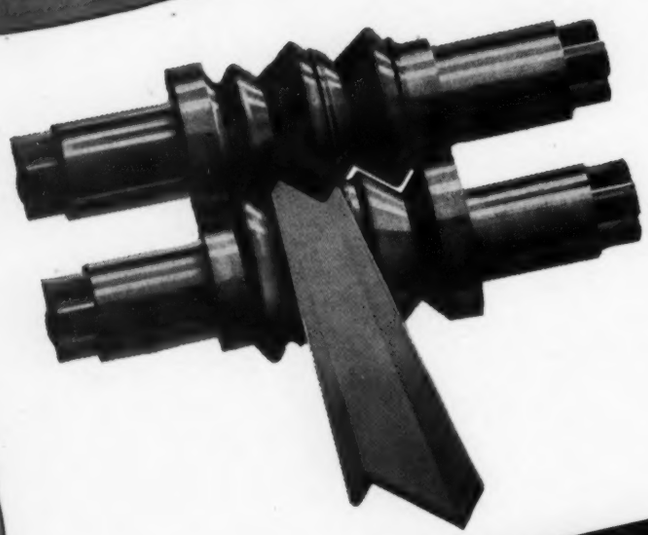
Farrel-Birmingham

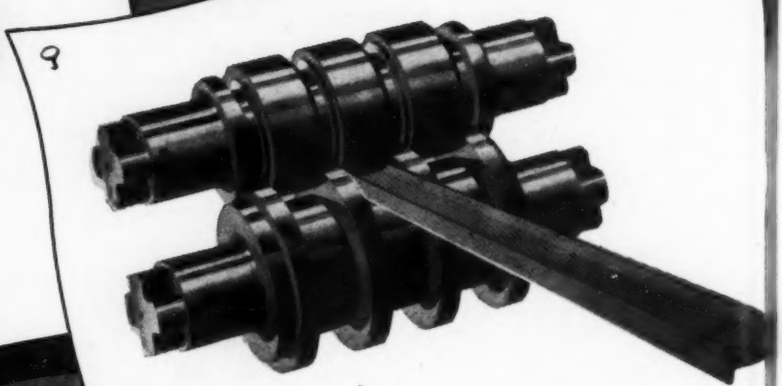


LESS COST PER TON OF STEEL ROLLED

Regardless of the shapes you specialize in, you'll find that Pittsburgh Rolls do the work more accurately at less cost per hour—or per year. The reason? They're made by a company manufacturing one product only—Rolls for Rolling Mills.

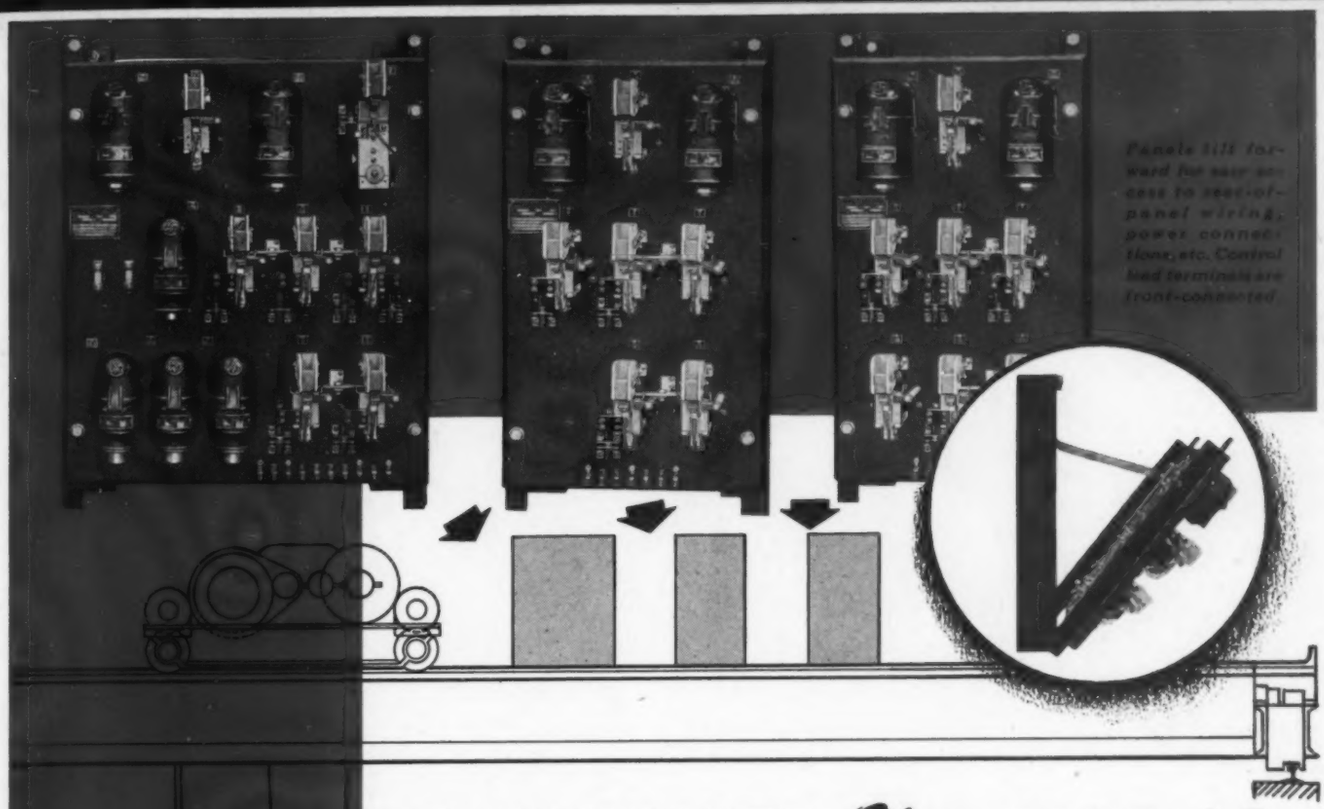
BUY MORE WAR BONDS AND STAMPS





PITTSBURGH ROLLS

PITTSBURGH ROLLS DIVISION of BLAW-KNOX CO. — "Steel's Partner" — PITTSBURGH, PA.


Panels tilt forward for easy access to rear-of-panel wiring, power connections, etc. Control load terminals are front-connected

A COMPLETE *New* LINE OF PUSH BUTTON CONTROL

for D-C FLOOR-OPERATED CRANES

★

COMPACT—EASY TO MOUNT—EASY TO WIRE—PROVIDES ACCURATE SPEED REGULATION

Here is a standardized line of controllers designed for (1) accurate inching, (2) compact mounting, and (3) minimum collector-bar requirements. They can be conveniently installed along the crane girders or mounted on the trolley, as required.

They have all the advantages of the well-known EC&M Control for *cab-operated* cranes. Acceleration is by the TIME-CURRENT method. Contactors are of the heavy-duty, magnetic type. Resistors are carefully proportioned for low-torque hoisting of light loads and for smooth acceleration of bridge or trolley. All motions can be controlled from a single, pendant, master-station complete with Pilot Light, Reset Button, and Emergency Stop, Double Pole control-circuit, Toggle Switch with two Push Buttons for each motion. Individual rope-operated Master Switches for the various motions are optional.

Bulletin 922 is a NEW bulletin giving complete data, description, dimensions, etc. Send for your copy today.

E&M

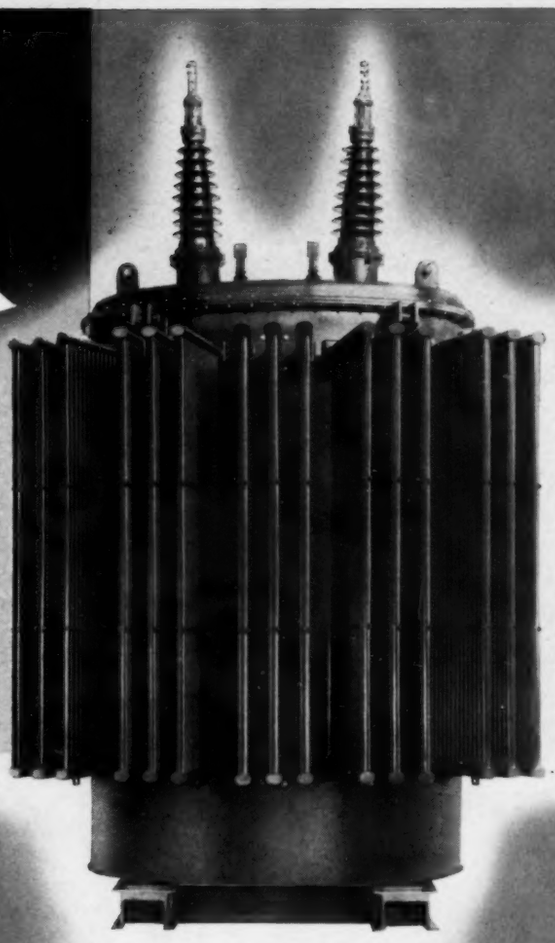
THE ELECTRIC CONTROLLER & MFG. CO.

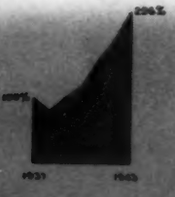
2698 EAST 79TH STREET — CLEVELAND 4, OHIO

MEETING TODAY'S

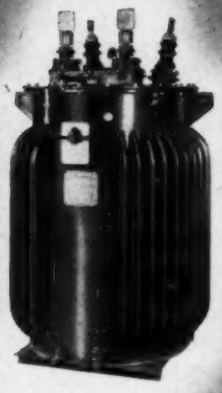
POWER

DEMANDS





Increase in Large Commercial and Industrial Power Consumption.



Increase in Small Commercial and Industrial Power Consumption.

Increase in Domestic Power Consumption.

Electric Power is the life-line of our Country's war effort. Fulfilling its mission as the "Arsenal of Democracy", the United States has undertaken an industrial program of staggering proportions. The demands for electric power have been increasing at an amazing rate. The Utilities are meeting this situation completely and efficiently. Although the reserve power capacity is appreciably reduced and the available equipment overloaded, the entire power supply system is kept in a highly satisfactory running condition by the untiring efforts of the Utility organizations.

Pennsylvania Transformer Company is proud to have a part in assisting the Power Companies during this period — by furnishing dependable transformers capable of carrying heavy overloads safely.

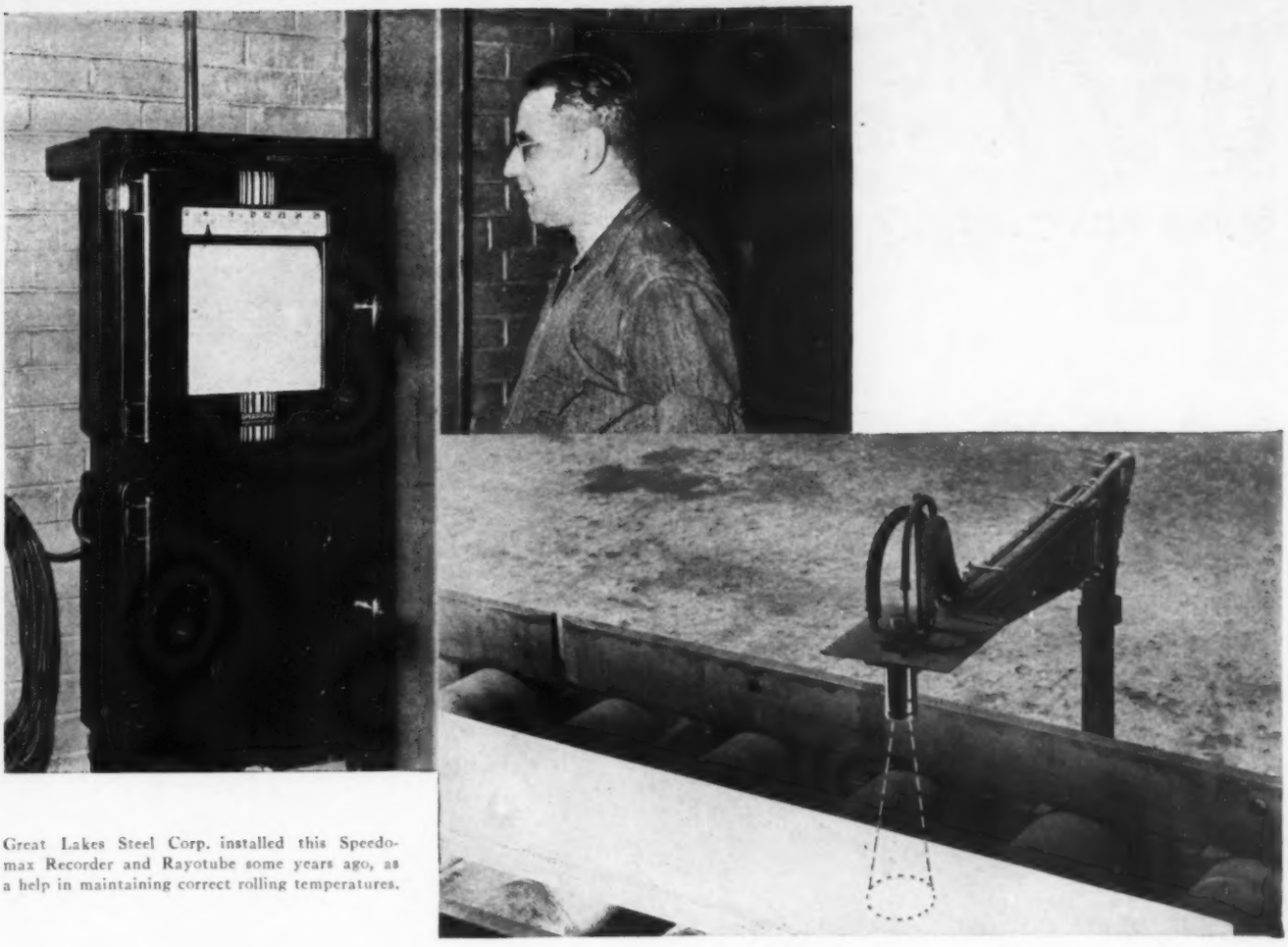
(Statistics shown in graphs courtesy of E.E.I.)

Write for our Distribution Catalog No. 142.

Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER COMPANY

PITTSBURGH PENNSYLVANIA



Great Lakes Steel Corp. installed this Speedomax Recorder and Rayotube some years ago, as a help in maintaining correct rolling temperatures.

"GREAT LAKES" Catches Temperature On The Fly--with Speedomax Recorders

"The billet was rolled too cold (or too hot)" is a report which we are told is seldom made in the mill where the above-shown Speedomax Recorder is used. And the reason is obvious; the Speedomax not only measures the temperature but records it, and everyone concerned knows all about the record. It bridges the gap of information which previously existed between the record of furnace temperature (kept by Micromax Recording Controllers) and the metallurgical department's Optical-Pyrometers checks. And Speedomax can be used anywhere in this gap — at any pass from the roughing mill to the last stage in the rolling of rod, rail, strip or plate. It helps heaters and rollers cooperate to put every billet through at the specified temperature.

The equipment consists of the vacuum-tube Speedomax Recorder itself, and a Rayotube radiation-detecting thermopile which, for all its high sensitivity, is enormously sturdy. In fact, the first detail which steel mill men notice about Speedomax is its absolute indifference to vibration and even position. It can be installed anywhere in the mill, and requires no more care than a Micromax thermocouple pyrometer.

Many temperature ranges are available, one of the most popular being 1200-2500, as shown above. If you would be interested in further information, an L&N engineer will gladly work on a specific application, or send you a catalog, as you prefer.

V depends on me!
A Slogan For Every American

Jrl Ad N-33B-685(1)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

SKIN ALLOY BLOOMS, BILLETS, SLABS in ½ the time

WITH AIRCO HEAVY DUTY SCARFING TORCHES

Compare the wide, shallow cuts made by an Airco Heavy Duty Scarfing Torch on the billet section at right with those made by a standard torch (above).

AIRCO Heavy Duty Scarfing Torches (Series 5200 and 6100) were designed especially to meet wartime manpower shortages and relieve billetshed bottlenecks.

Instead of the usual 1" to 1½" cut, they will easily scarf a shallow path 2½" or wider with no greater oxygen consumption per square foot removed than that of ordinary torches. Moreover, by reason of the shallowness and speed of the cut, less surface metal is removed.

Actual production figures, based on the records of a number of alloy mills show scarfing tonnage increases of as much as 30% effected by the use of these torches. Indications are that this figure can be considerably increased if facilities are provided for more rapid handling of the steel.

Ask your nearest Airco office for new catalog circular ADC-635 describing these tonnage-boosters—or write direct to Department IS at the New York office.

★ BUY UNITED STATES WAR BONDS ★

AIRCO WILSON

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

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Offices in all Principal Cities

MESTA

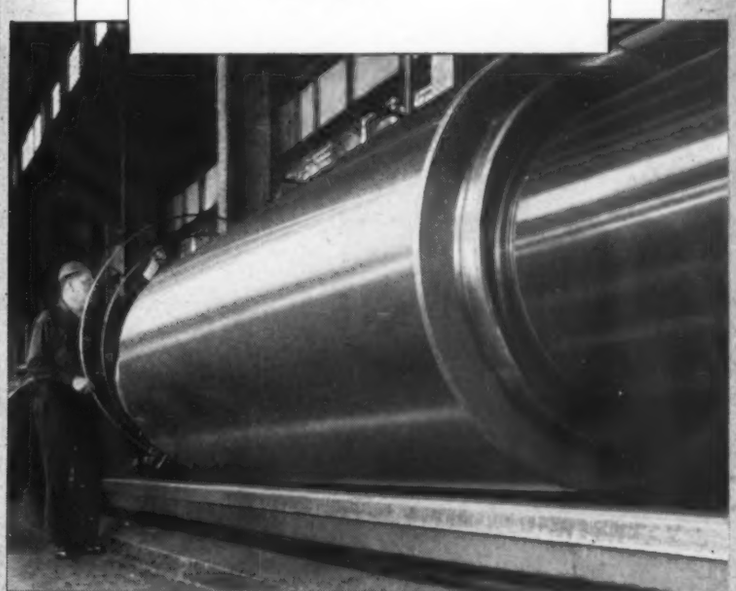
SPECIAL ALLOY CAST STEEL BACKING-UP ROLLS

Rolls are cast in the Mesta Foundry from molten steel produced in our own Open Hearths...

Mesta engineers, metallurgists and foundrymen have devoted their entire careers to the production of rolls for the hot or cold reduction of ferrous and non-ferrous materials. To assist them in producing rolls of the highest quality to accommodate the rolling conditions in each individual mill, these men have at their disposal all the necessary equipment and materials from which to make the proper selection. There is a Mesta Roll for every type of service.

After annealing and rough turning, these rolls receive further heat treatment to produce the desired hardness...

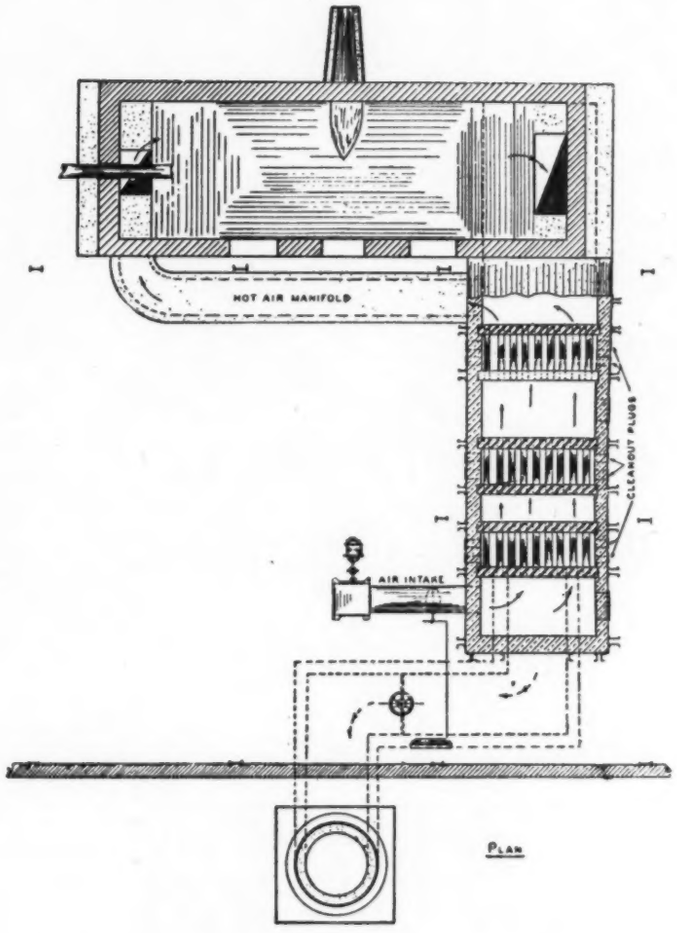
Finishing is done in Mesta Heavy Duty Roll Grinders in our own shop.



The Army-Navy "E" Flag with four stars, flies over the Mesta plant

MESTA MACHINE COMPANY • PITTSBURGH, PA.

"FITCH" RECUPERATORS for OPEN HEARTH



The maximum production of a furnace is made possible by firing in one direction continuously. It is not necessary to reverse the flame in relatively small capacity furnaces equipped with a "Fitch" recuperator.

The design illustrated shows a standard small capacity regenerative open hearth furnace converted to a non-reversing recuperative furnace.

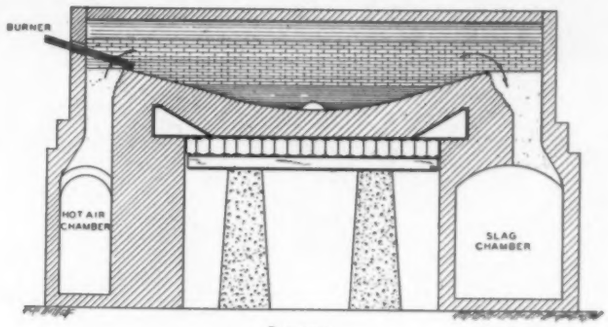
The "Fitch" silicon carbide tubular heat transfer elements will withstand any temperature or chemical reaction found in open hearth practice. Their life is greater than any known material used for this work.

The life of the "Fitch" recuperator as a whole is prolonged over an indefinite period of time by the ability to replace individual parts without disturbing the balance of the structure. Cost of replacements, per ton of steel poured, is negligible.

The first cost of the recuperator is no greater than the cost of the conventional regenerators and reversing valve equipment.

FITCH RECUPERATOR COMPANY

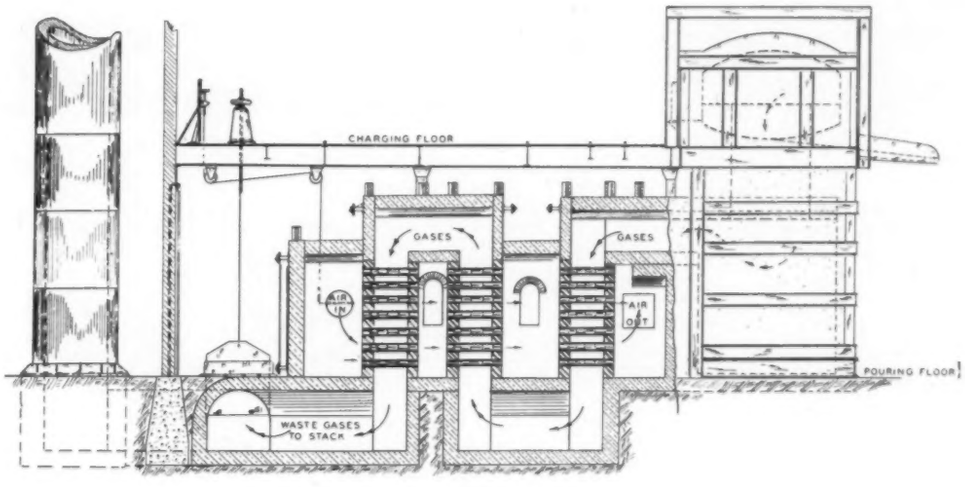
PLAINFIELD NATIONAL BANK BLDG. PLAINFIELD, NEW JERSEY



ELEVATION

The furnace design is not changed other than the remodeling of one slag chamber to form the hot air uptake.

The existing hot air port from the slag pocket level to the burner remains unchanged, utilizing the heat in the furnace brickwork to further increase the temperature of the air leaving the recuperator.



ELEVATION & SECTION

The air for combustion enters the furnace with the fuel in the conventional manner. Air passages cannot clog up as they are used for the passage of air only.

Firing continuously in one direction is ideal for control by instruments.

Write for Bulletin No. 12

"FITCH" RECUPERATORS for the STEEL INDUSTRY

WE DO NOT BUILD FURNACES — SEE YOUR FURNACE BUILDER

We asked a Superintendent why he prefers

SALEM CIRCULAR SOAKING PITS . . .

. . . and this is what he told us

1. "Substantial Savings on my conditioning costs . . .

"A superintendent judges mill equipment in savings per ton of steel. After checking the Salem Pit for 6 years, I can tell you that it substantially helps the cost picture.

2. "Less maintenance and easier maintenance . . .

"Except for adjustment of the heating burners, we haven't touched our 20' diameter Salem Pit since it was built. When we do repair, we won't have any expensive arches or checker work to replace.

3. "Good quality . . .

"Accurate heating control keeps the amount of poorly heated steel to practically zero. You can set burners and forget about it until ingots are ready.

4. "25% faster heating cycle . . .

"Because all ingots in a Salem charge can be maintained at same temperature, you get better surface, less scale, faster and safer rolling. The circular design eliminates the dead hard-to-heat corners.

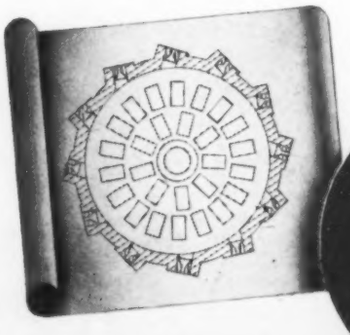
5. "Best cover on any pit . . .

"The cover on our Salem Circular Pit has been in service 6 years and is still going strong. You have less spalling because the cover doesn't lose heat when off the pit and since you have a central outlet for waste gases, with good circulation you have much less deteriorating action when cover is in place.

6. "Less chance for human errors . . .

"The Salem Pit depends less upon skill of the operator than any other type of pit. You have less guesswork, therefore, less trouble.

"Summing up, I like the Salem Circular Soaking Pit because you save money on conditioning, you can prepare your ingots faster, and you have less trouble in the entire operation than with any other type pit. I would like to have all Salem Pits in my plant."



Salem builds circular soaking pits in various sizes, ranging from 8' to 20' in diameter.

SALEM ENGINEERING COMPANY

Your inquiry will receive prompt attention!

SALEM ENGINEERING CO. · SALEM, OHIO

Want to *reduce* production costs?

Do you want to lay the foundation for your success in post-war competition? Start pruning the operating expense of heavy duty equipment. This is today's essential step toward the plant efficiency demands of peacetime business. It's an immediate help in war production. It's one problem that offers an efficient approach.

Mackintosh-Hemphill has been making industrial headlines since 1803. In their sphere of manufacturing, metallurgy and engineering, their services might prove of extreme value to you. They offer you an experienced source of advanced thinking.

THE ROLLS WITH THE RED WABBLERS
THEY ROLL MORE TONS PER GRIND

Install

Nironite C-B work rolls

Mackintosh-Hemphill has been the originator of practically every major roll development. Their Nironite Rolls, in actual service, have repeatedly demonstrated 300% greater wearing qualities than ordinary rolls.

M-H Nironite Rolls are high nickel chromium alloy iron, of the grain or indefinite chill type. The body surface structure very closely approaches that of true chill and the body centers and necks are tough and strong. They are ideal for flat work. These rolls are rapidly supplanting the true nickel chill types for Strip Mill Intermediates. They will not spall; give better finish and greater tonnage per grind. Because of their surface likeness to chill and freedom from spalling, the Hard Grade "D" is replacing Forged and Hardened Steel Rolls for Cold Work.

MACKINTOSH-HEMPHILL COMPANY
Pittsburgh and Midland, Penna.

DETROIT PUBLIC LIBRARY

1803

EXPERIENCE FOR SALE

Mackintosh-Hemphill's experience has been accumulating for 140 years. It is the solid foundation upon which present, progressive M-H technical minds have built their international reputation for successful industrial leadership. Today its benefits are available to you through their cooperative consulting service on the mechanical engineering end of industrial production equipment.

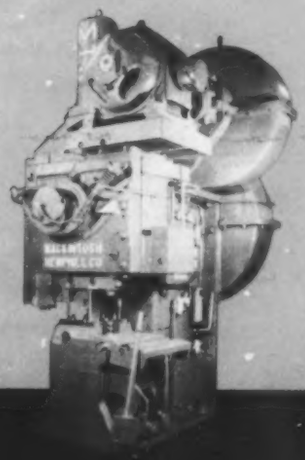
MACKINTOSH-HEMPHILL is constantly demonstrating the ability to transmute a wealth of past experience into a solution of the problems of its customers.

ONE HUNDRED YEARS AGO, they produced the first chilled roll in the United States for rolling sheet brass.

FIFTY YEARS AGO, they accomplished the first 3-stand continuous tin plate cold rolling.

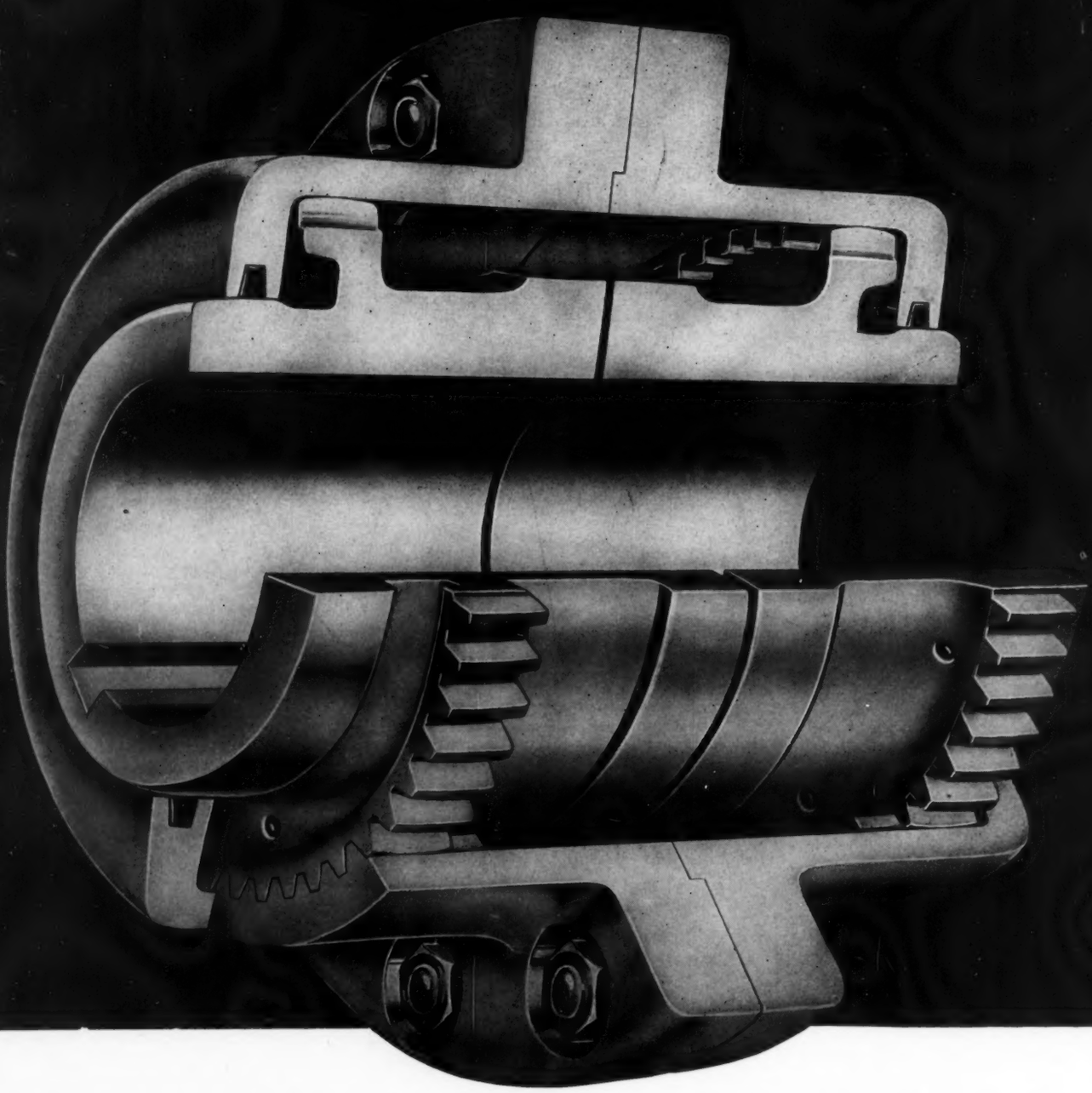
LAST YEAR at Uncle Sam's request, they produced heavy-duty lathes that remove metal 2 to 3 times faster than ordinary tools.

TODAY, they have just completed the shear below that utilizes a new type of ram design. This shear can handle a wide range of loads with constant, maximum efficiency . . . Assuring greater production, cleaner and more accurate cuts regardless of load distribution.



OTHER PRODUCTS:
Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron-Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports . . . Heavy Duty Engine Lathes.

POOLE



COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

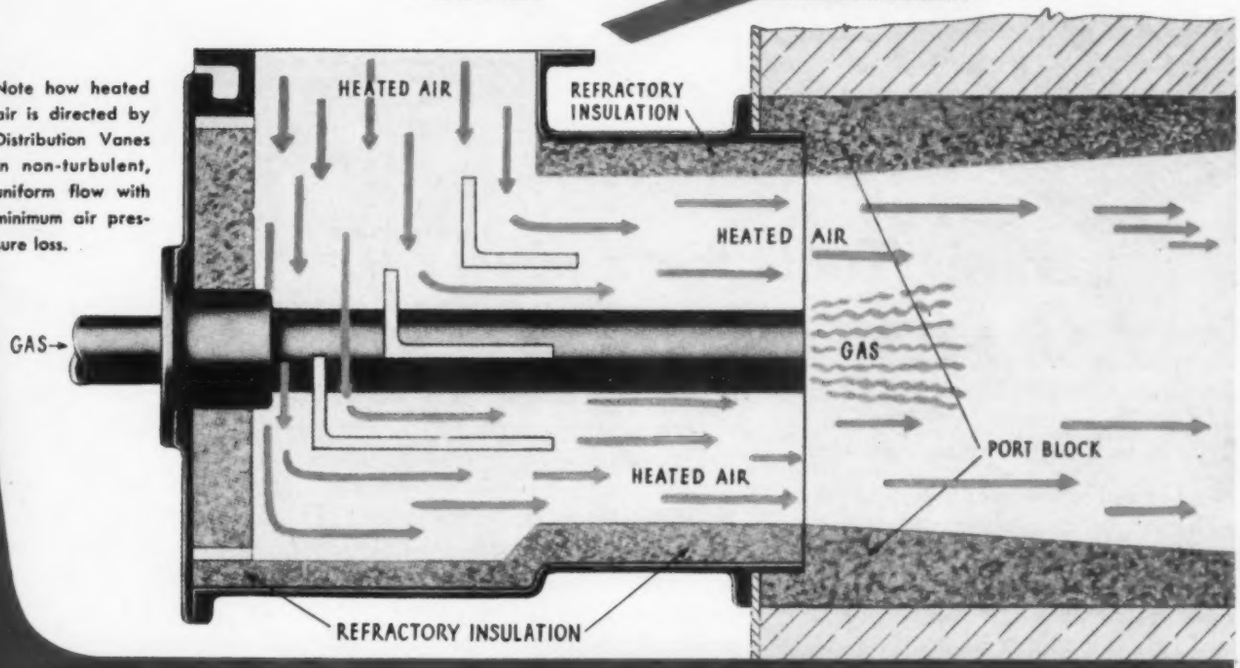
POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

BLOOM Hot Air Burners

. . . increase efficiency without excessive flame temperature when used with

★ **NATURAL GAS**
★ **COKE OVEN GAS**
★ **MIXED GAS**
★ **OIL or TAR FUEL**

Note how heated air is directed by Distribution Vanes in non-turbulent, uniform flow with minimum air pressure loss.



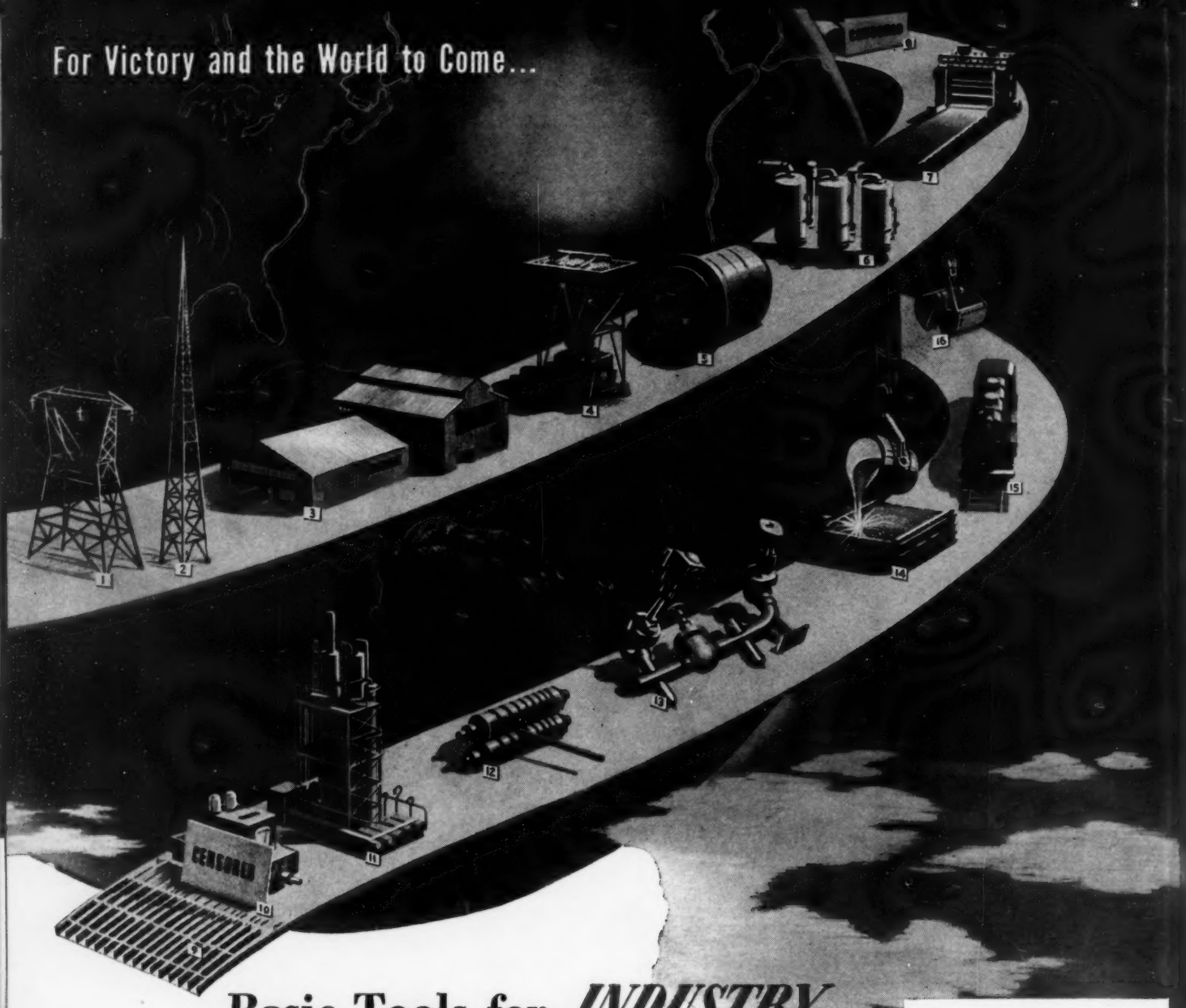
Bloom Hot Air Burners are designed for maximum operating efficiency with combustion air preheated from 600°F to 1500°F. The burner body is built with a cast refractory lining to withstand these high temperatures. Applicable wherever better combustion is vital . . . for soaking pits, billet heating furnaces, melting furnaces and air furnaces. Bloom engineers are available for consultation anytime, anywhere on any industrial combustion problem.

Write for Bloom Bulletin No. 1020

BLOOM ENGINEERING CO.

857 W. NORTH AVE., PITTSBURGH 12, PA.

For Victory and the World to Come...



Basic Tools for *INDUSTRY*

The above "inkling" of the scope of Blaw-Knox products and services must impress any industrialist with the fact that Blaw-Knox possesses skills, facilities, engineering experience of an order to make it truly a partner of industry.

For ferrous and non-ferrous industries Blaw-Knox has long produced rolling mill machinery, rolls and other basic equipment. Its leadership is equally emphatic in fabricated products for railroads, public utilities, the electronic industry and general industry. Among contractors, Blaw-Knox is synonymous with speed, efficiency and economy. In the process and chemical fields, Blaw-Knox products include all types of equipment as well as engineering and research based upon long experience.

With Blaw-Knox services and products go the *plus* value of an industry-wide background . . . of ability to think beyond the product into its ultimate uses. A discussion of your special problems is invited.

THE ILLUSTRATION presents a partial idea of Blaw-Knox Products and Services.

1 Transmission Towers
2 Radio Towers
3 Standard Buildings
4 Construction Equipment
5 Steel Forms for Concrete Construction
6 Chemical Plant Equipment
7 Rolling Mill Machinery
8 Electronic Equipment (censored)
9 Open Steel Flooring
10 Another censored line o. products
11 Complete Process Plant Units
12 Rolls for Rolling Mills
13 Prefabricated Power Piping
14 Special Castings
15 Castings for Locomotive Frames, Crossheads and Wheel Centers
16 Clamshell Buckets

Buy U. S. War Bonds and Stamps

A PACEMAKER FOR AMERICAN INITIATIVE AND INGENUITY

BLAW-KNOX COMPANY

2040 FARMERS BANK BLDG., PITTSBURGH, PA.

LEWIS FOUNDRY & MACHINE DIVISION, Rolls and Rolling Mill Machinery

POWER PIPING DIVISION, Prefabricated Piping Systems

NATIONAL ALLOY STEEL DIVISION, Heat and Corrosion-Resistant Alloy Castings

PITTSBURGH ROLLS DIVISION, Rolls for Steel and Non-Ferrous Rolling Mills

BLAW-KNOX DIVISION, Chemical & Process Plants & Equipment, Construction Equipment, Steel Plant Equipment, Radio & Transmission Towers . . . General Industrial Products

COLUMBUS DIVISION, Ordnance Matériel

UNION STEEL CASTINGS DIVISION, Steel and Alloy Castings

MARTINS FERRY DIVISION, Bofors Anti-Aircraft Gun Mounts

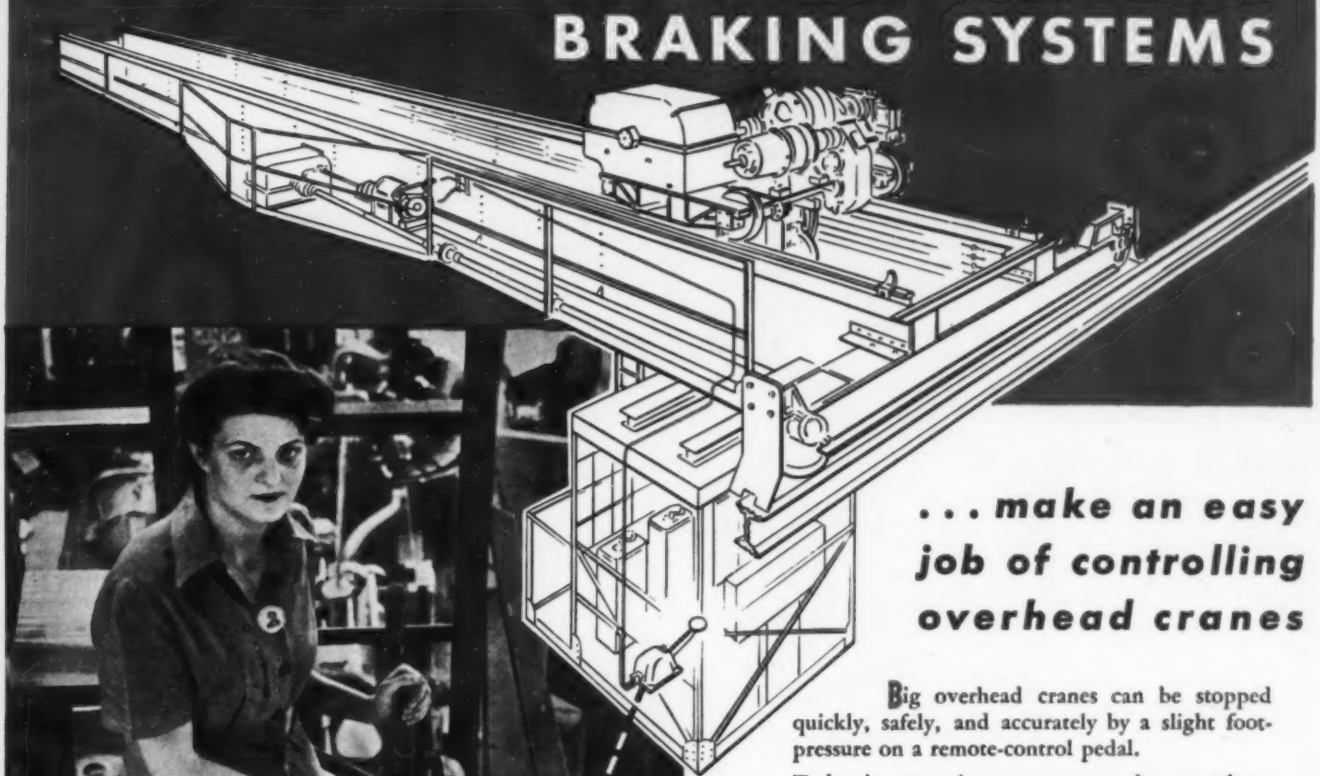
BLAW-KNOX SPRINKLER DIVISION, Automatic Sprinklers and Deluge Systems

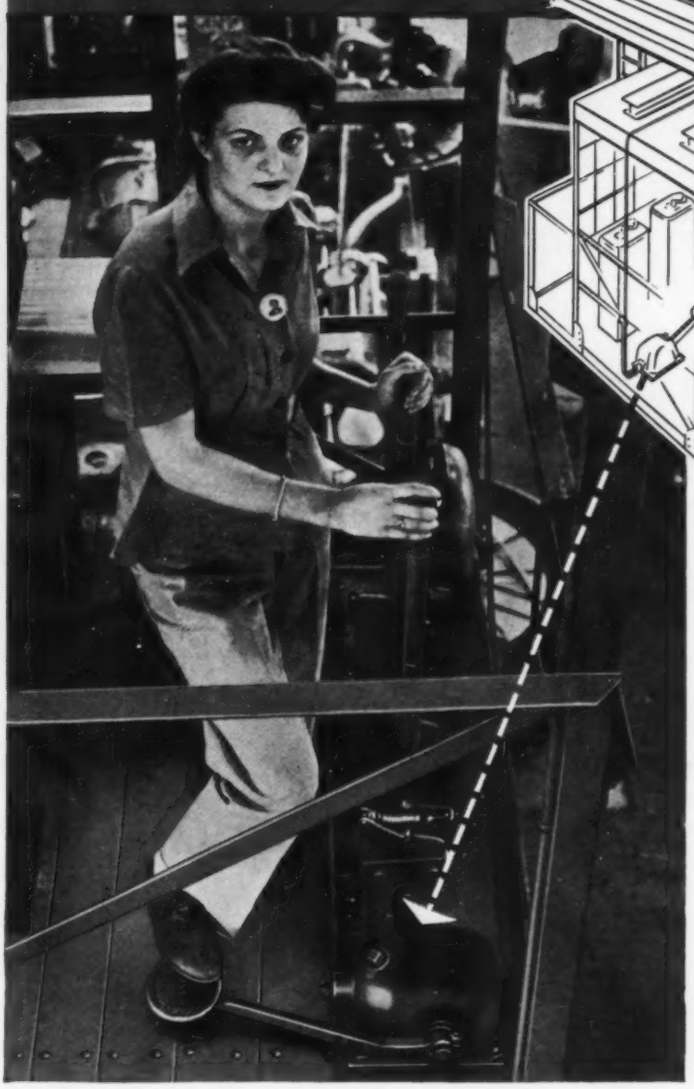
Four Blaw-Knox Plants have been awarded the Army-Navy "E" for war-production excellence

A FEW VICTORY PRODUCTS

ANTI-AIRCRAFT GUN MOUNTS · GUN SLIDES · LANDING BARGES · POWDER PLANTS · PIPING FOR NAVAL VESSELS · SYNTHETIC RUBBER PLANTS · CAST ARMOR FOR TANKS & NAVAL CONSTRUCTION · CHEMICAL PLANTS

Wagner INDUSTRIAL HYDRAULIC BRAKING SYSTEMS





. . . make an easy job of controlling overhead cranes

Big overhead cranes can be stopped quickly, safely, and accurately by a slight foot-pressure on a remote-control pedal.

Today in many instances women in war plants have taken over that job—Wagner industrial hydraulic brakes have made it possible. These efficient industrial hydraulic brake systems are used extensively, not only on overhead cranes, both for indoor or outdoor operation, but also on bending-rolls, scrap-balers, large wheel-balancers, and similar applications when it is desirable to decelerate the machine by foot-pressure for either normal or emergency stops.

Write for Bulletin IU-20

Users of overhead cranes, as well as every maintenance man responsible for the safe and efficient operation of overhead cranes, should have this bulletin. A post-card will bring it to you.

I 44-11

The above illustration is one of the twelve cranes operated by women at a large midwest war-production plant.

BACK THE ATTACK — BUY U. S. WAR BONDS

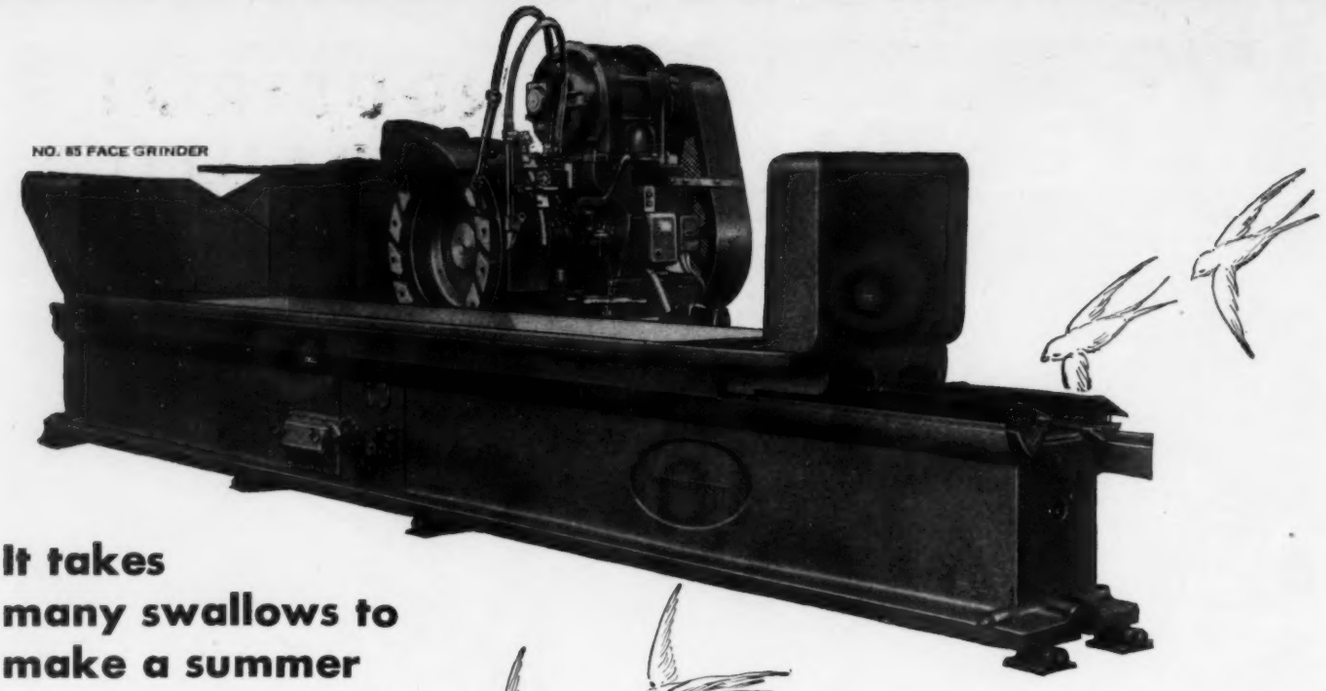
MOTORS
TRANSFORMERS
UNIT SUBSTATIONS
INDUSTRIAL BRAKES
BRAKE LINING

Wagner Electric Corporation

ESTABLISHED 1891

6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS



It takes many swallows to make a summer

AND MANY GOOD POINTS TO MAKE A REALLY FINE MACHINE

If interested in Surface Machining it will pay you to note these features

FLAT SURFACES PRODUCED BY FACE GRINDING FASTER MORE ACCURATELY THAN BY OTHER METHODS

◆

USED FOR:
GUIDE BARS
LOCOMOTIVE PARTS
SHEAR KNIVES
FORDING DIES
ALL FLAT SURFACES

Hydraulic Operation — Table travel, 120 ft per minute; smooth, shockproof reversal.

Bridgeport Sectional Grinding Wheel — For maximum stock removal and fast, cool cutting. Wheel design brings coolant into cutting edges.

Central Control — All operating controls at fingertips of operator.

Bridgeport Timken Spindle — A proven design making for rigidity and accuracy.

Pressure Lubrication of ways and bearings with oil filter.

Power — Ample for heaviest requirements yet under instant control.

Safety in Unloading — Depressing a foot treadle clears table of operating dogs for safe unloading.

Auxiliary Controls — Hand reversal for instant table reverse. Spindle brake for stopping the wheel quickly.

Extreme Rigidity due to proper designing, with reserve material where stability is needed.

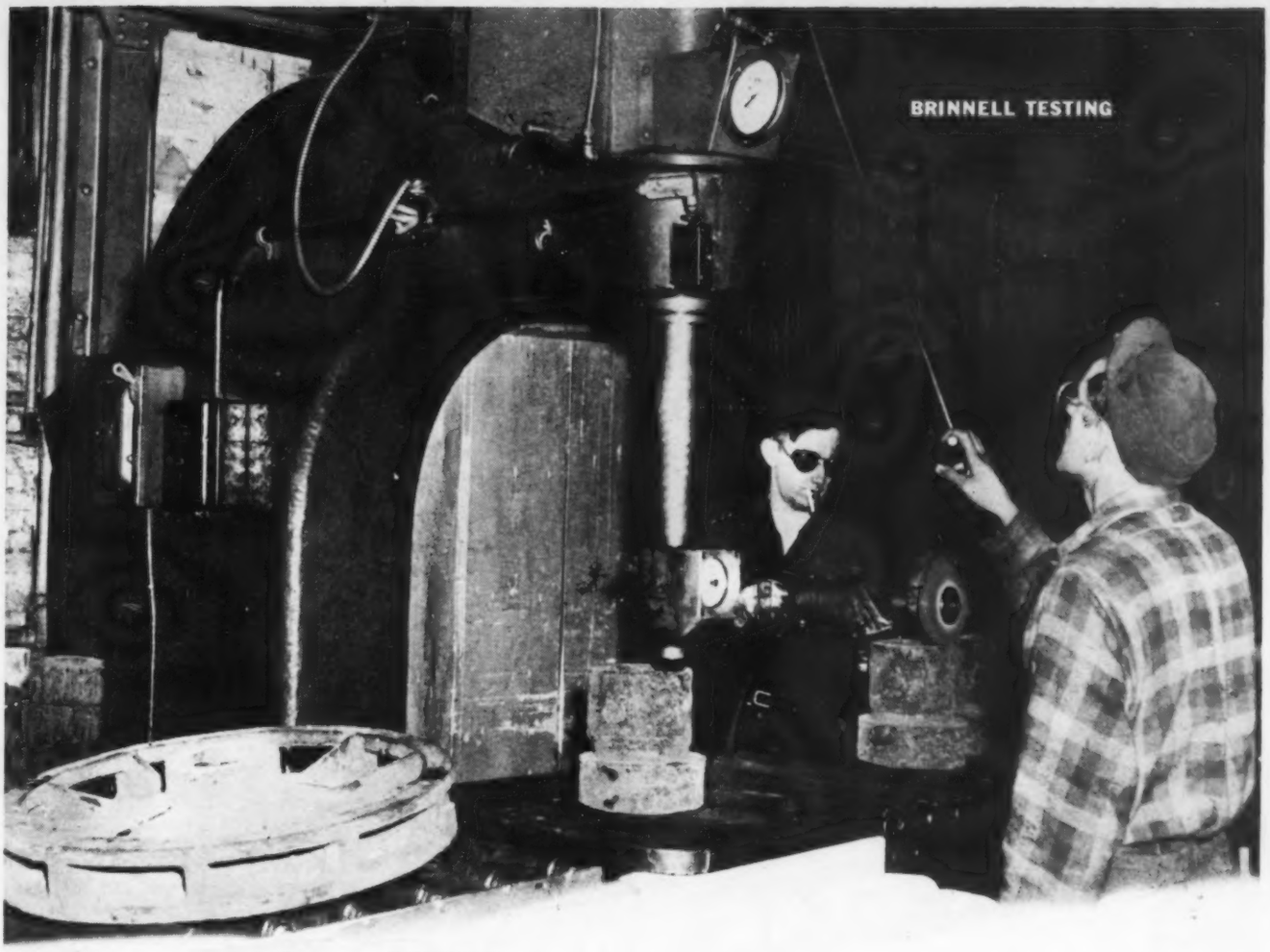
Ample Coolant — System includes two nozzles, fully adjustable, also flushing hose. Large coolant reservoir.

Further details on request.

THE BRIDGEPORT SAFETY EMERY WHEEL CO., BRIDGEPORT, CONN., U. S. A.

Bridgeport

GRINDERS • GRINDING WHEELS • BUFFING LATHES



QUALITY
STEEL CASTINGS

CONTINENTAL quality carbon and alloy steel castings are produced under high standards of craftsmanship and must meet complete inspection requirements before leaving the factory.

Continental's vast production capacity with modern equipment, special machinery, complete heat treating facilities and special inspection devices are the answer to Continental leadership in the steel casting industry. *Continental Foundry & Machine Company, Chicago—Pittsburgh.*

CONTINENTAL FOUNDRY & MACHINE COMPANY

CHICAGO · PITTSBURGH

FORMERLY
CONTINENTAL ROLL & STEEL FOUNDRY COMPANY

DURING the exigencies of the past several years our major effort has been the production of gears and speed reducers for the war effort. In the production of essential materials we have a commendable record of service.

Notwithstanding the pressure of war work, our engineers have been able to devote some time to the development of an improved type of air cooled worm gear speed reducer. This new machine has remarkable capacity for increased ratings, under continuous operation in the higher range of motor speeds, when compared with the conventional type of unit.

We are making this preliminary announcement because the benefits to be gained by the use of the Jones AIRCLAD units will have a marked effect on worm gear speed reducer practice and the industrial application of drives in the future.

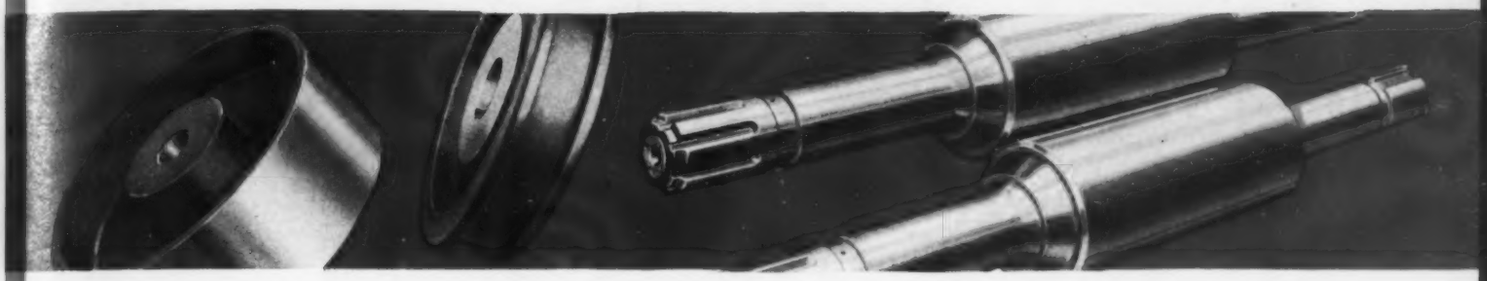
Complete catalog information is not ready for distribution at this time. However, as soon as conditions permit of our making this fan-cooled reducer commercially available, industry will be offered a product that is second to none in design, construction and dependability—a reducer that will be a worthy addition to the line of time-proven Jones products.

W. A. JONES FOUNDRY & MACHINE CO., 4431 Roosevelt Rd., Chicago 24, Illinois

Jones

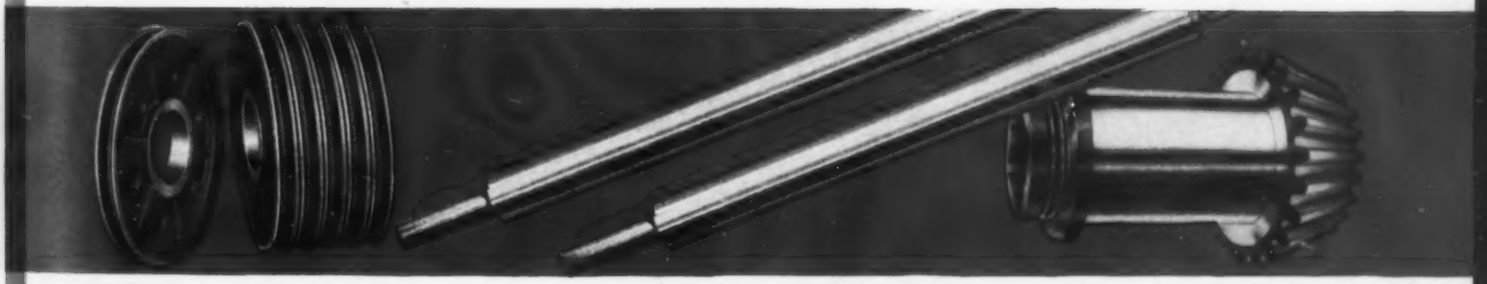
HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS
PULLEYS • GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • FLEXIBLE COUPLINGS

YOU'LL GET *Plus* PRODUCTION



with "TOOL STEEL"

GEARS · PINIONS · ROLLS · WHEELS AND HARDENED PRODUCTS



Plus **Production will be most important in the post-war competitive era. Better find out *Now* what *"Tool Steel" Hardened Products* can do for you. Write for Bulletins.**

THE TOOL STEEL GEAR & PINION COMPANY

CINCINNATI, OHIO

And there's more War Bond money, too, for everybody in the mill when Lewis Rolls are in the stands. They account for greater tonnage, better finish, fewer rejects and less time out for roll change. So, look to Lewis for long-lived service.

LEWIS FOUNDRY and MACHINE DIVISION
of Blaw-Knox Company
P. O. Box 1586, Pittsburgh, Pa.

Also manufacturers of
ROLLING MILL MACHINERY
for the iron, steel and non-ferrous industries

LEWIS ROLLS

This McKay Electric Weld Tube Mill

uses 146 Timken Bearings

The McKay Machine Company, Youngstown, Ohio took full advantage of its past experience with Timken Tapered Roller Bearings when designing this mill. Thus, no vital points of precision and hard service have been overlooked.

The machine comprises a forming section (8 stands), a sizing section (3 stands), a welding unit and a rotary pipe cut-off unit. There are 132 Timken Bearings in the forming and sizing sections, (12 bearings per stand); 10 Timken Bearings in the welding unit; and 4 Timken Bearings in the cut-off unit; a total of 146 Timken Bearings, providing maximum protection against friction, wear, radial, thrust and combined loads and misalignment of moving parts.

So revolutionary have been the results of the wide-spread use of Timken Bearings in the steel industry for all kinds of equipment, that it is doubtful whether the tremendous demand for steel for the war effort otherwise could have been met. The Timken Roller Bearing Company, Canton 6, Ohio.

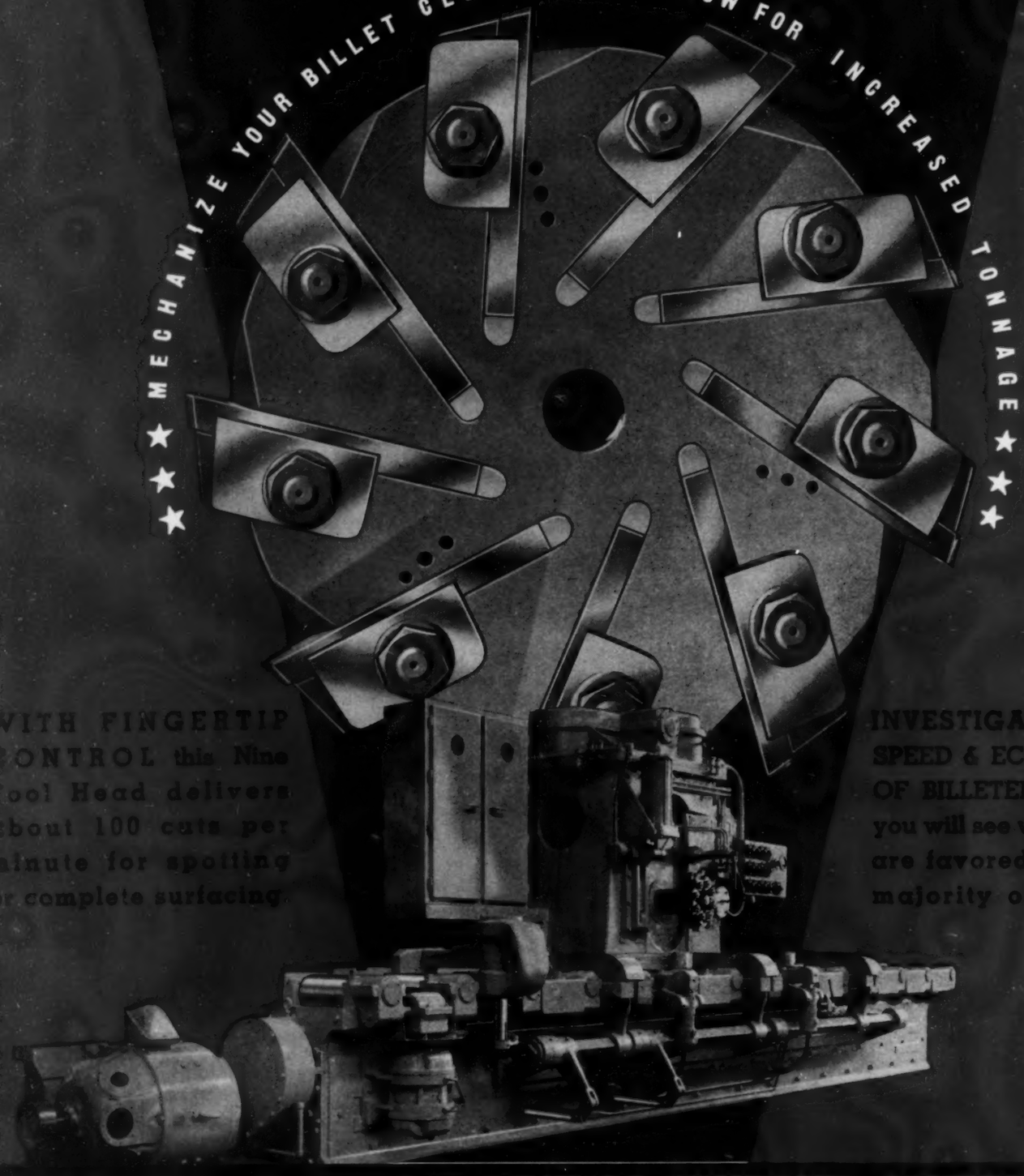
TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

This Cutting Head Makes Short Work of Billet Cleaning

★ MECHANIZE YOUR BILLET CLEANING JOB NOW FOR INCREASED TONNAGE ★



WITH FINGERTIP CONTROL this Nine Tool Head delivers about 100 cuts per minute for spotting or complete surfacing

INVESTIGATE THE SPEED & ECONOMY OF BILLETEERS and you will see why they are favored by the majority of mills.

STEEL EQUIPMENT DIVISION OF **THE BONNOT COMPANY, CANTON, OHIO**

BONNOT

ENGINEERED FOR IMPROVED PRODUCTION

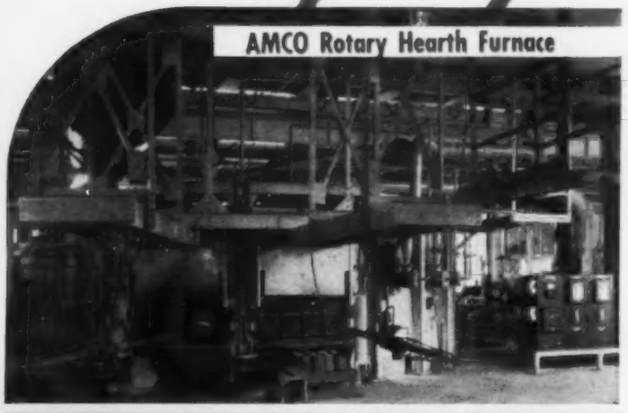
WRITE US FOR COMPLETE FACTS

AMCO Equipment FOR

AMCO Pit Furnace

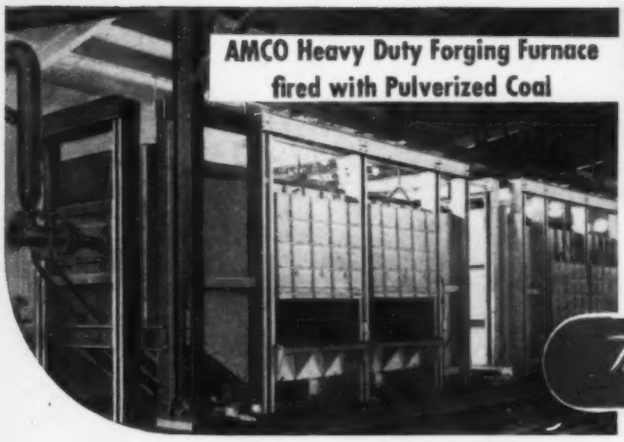
HEATING · MELTING ANNEALING

AMCO is today playing a vital part in the nation's war-production program, resulting in a wealth of specialized experience that is at your command now or for post-war planning, to meet the widely varied problems of heating, melting and annealing.

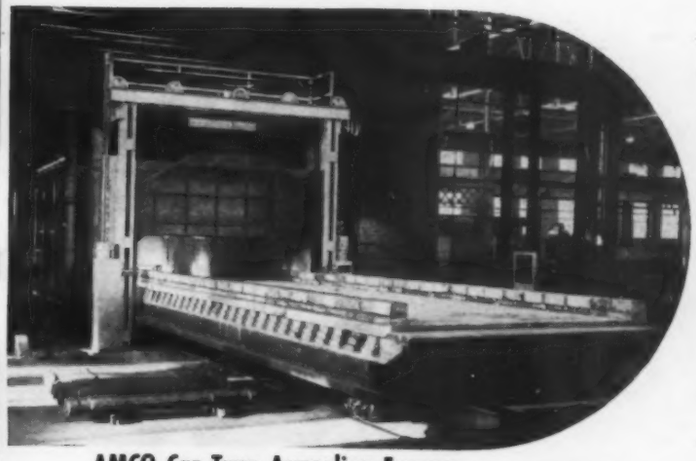


AMCO Rotary Hearth Furnace

AMCO Open Hearth Furnace

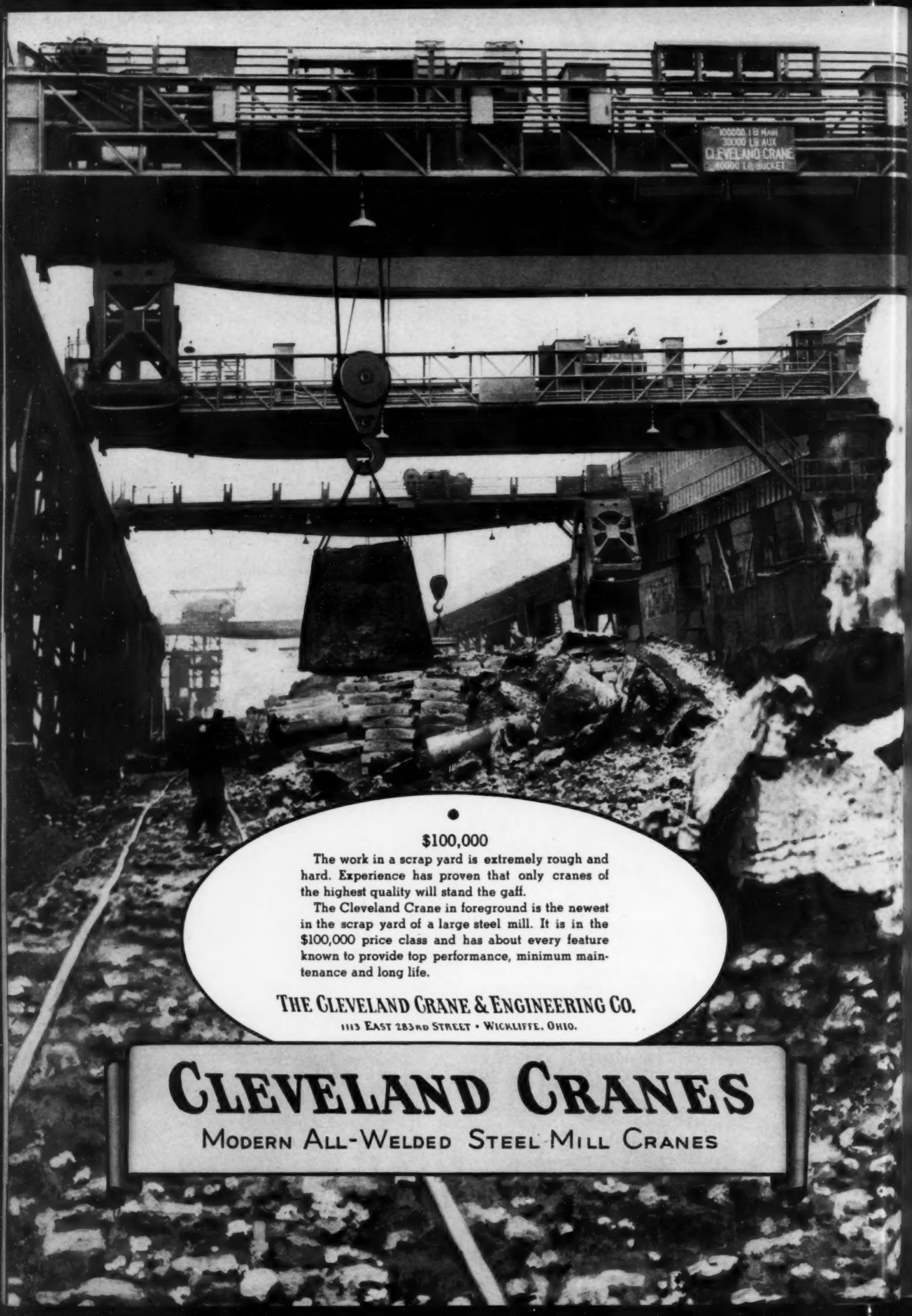


AMCO Heavy Duty Forging Furnace fired with Pulverized Coal



AMCO Car Type Annealing Furnace

The AMSLER - MORTON Company
FULTON BUILDING · PITTSBURGH, PA.



$100,000

The work in a scrap yard is extremely rough and hard. Experience has proven that only cranes of the highest quality will stand the gaff.

The Cleveland Crane in foreground is the newest in the scrap yard of a large steel mill. It is in the $100,000 price class and has about every feature known to provide top performance, minimum maintenance and long life.

THE CLEVELAND CRANE & ENGINEERING CO.

1113 EAST 283RD STREET • WICKLIFFE, OHIO.

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

THERE is a growing opinion that much postwar activity in the steel industry will fall along lines of further finishing of steel products, particularly as regards heat treating, coating, forming, etc. Such activities are not new to the industry, but have been rather limited in scope. In many cases, experimental work indicated the feasibility of such projects, but sufficient pressure was lacking to cause the processes to be fully exploited. In the postwar years, however, aluminum, magnesium and brass, with annual capacities of 1,100,000, 300,000 and 500,000 tons respectively, to say nothing of plastics, will provide considerable impetus toward overcoming such inertia. It is generally felt that the industry will be forced to a much wider adoption of finishing processes in order to meet adequately the competition from other materials.

▲

WE hope that the Axis leaders aren't banking too much on the fact that the Yanks aren't at the top of the American league this year.

▲

IN spite of a record 45,061,874 net tons of ingots for the first six months of 1944, the recent drop in steel production is worrying Washington, and perhaps something will be done about the industry's manpower situation. The record half-year tonnage is based mainly on record monthly figures in the early 1944 months. June shows the lowest weekly figures in six months. In cool weather, the industry was able to maintain its production by a considerable amount of overtime work. Some 60 hour weeks have been reported, and 16 hour turns were common. Hot weather is now reducing the capability of workers to stand the long hours. The slump in production can be placed squarely upon the wholesale cancellation of draft deferments. Total employees in the industry averaged 569,000 during May in comparison with 632,000 in May, 1943.

▲

A PRODUCER of iron and steel uses 25,000 different commodities in his operations, according to statistics advanced by Republic Steel Corporation manufacturing work each month, according to Department of Labor statistics. Whether the new manpower rulings lower this figure remains to be seen.

▲

TO produce the 59¾ million tons of finished steel (89 million tons of ingots) made during 1943, the steel industry of the United States consumed the following materials, according to the American Iron and Steel Institute:

Fuel oil	2,109,425,000 gal
Tar and pitch	226,784,000 gal
Natural gas	868,172,000,000 cu ft
Electric power	18,380,000,000 kwhr
(40% of this generated in plants operated by the industry)	
Coal	90,905,000 tons
(84% for coking)	
To blast furnaces:	
Iron ore to blast furnaces	108,025,000 tons
Coke	56,701,000 tons
Limestone	24,248,000 tons
Cinder and scale	7,152,000 tons
Scrap	3,694,000 tons
To steel making furnaces:	
Pig iron	51,956,000 tons
Scrap	47,106,000 tons
Iron ore	7,385,000 tons
Cinder and scale	563,000 tons
Fluxes	6,534,000 tons

▲

ESTIMATES of the increased costs which would result from the granting of seven of the 14 U. S. W. A. demands are set at $691,400,000 per year. The demands included in the estimates are those for a 17 cents per hour wage increase, establishment of a fund for steelworkers in the armed forces, guaranteed annual wage, increased vacations with pay, sick leave with pay, shift premiums and group insurance. The average cost per man hour of these demands would be 58 cents, without including severance pay, premium pay for certain holidays, rate establishment and adjustments, etc. With the present rate at approximately $1.19, that wouldn't be a bad raise.

▲

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A PRODUCER of iron and steel uses 25,000 different commodities in his operations, according to statistics advanced by Republic Steel Corporation in its company magazine, "Republic Reports." These commodities are purchased from 10,000 suppliers. Not a bad market.

▲

LEST we forget, the postmaster general reminds us that Christmas mail for personnel of the armed forces overseas must be mailed between September 15th and October 15th. Parcels should not exceed 5 lb in weight or 15 in. in length or 36 in. in length and girth combined. They should be well packed and strongly wrapped. Addresses must be complete and legible, and a complete return address should also be shown. Postage must be fully prepaid. Perishable matter may not be mailed, and the sending of fragile articles is discouraged. Intoxicants, inflammable materials and poisons or compositions which may kill or injure another, or damage the mails, are unmailable.

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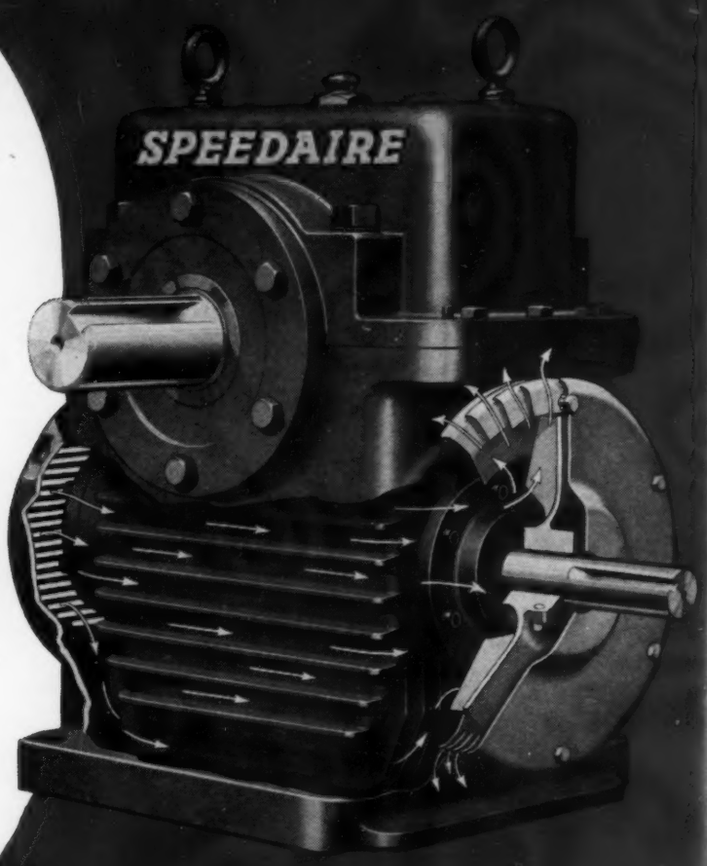

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In This Issue

Sponge Iron — Its Possibilities and Limitations — by C. F. Ramseyer, Metallurgical Engineer, H. A. Brassert and Company, New York, New York 35

Dust Collecting Systems — by F. C. Morey, Chief Engineer, Parsons Engineering Company, Cleveland, Ohio 45

Crane Bridge Symposium — by C. S. Shepherd, American Bridge Company, Ambridge, Pennsylvania; E. H. Windolph, Alliance Machine Company, Alliance, Ohio; W. C. Heinle, Cleveland Crane and Engineering Company, Wickliffe, Ohio and E. J. Posselt, Cutler-Hammer, Inc., Milwaukee, Wisconsin 52

Discussion: Crane Bridge Symposium — presented by James Farrington, J. A. Jackson, E. H. Windolph, F. E. Kling and C. S. Shepherd 62

Cold Roll Forming — by C. M. Yoder, President, The Yoder Company, Cleveland, Ohio 64

Improved Control for Runout Tables — by B. Starie, Industrial Control Engineering Division, General Electric Company, Schenectady, New York 73

Electronics in Industry — by C. J. Madsen, Electronics Engineer, Industry Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania 76

News Supplement 89
Equipment 89
Literature 100
Personnel 105

Index to Advertisers 127

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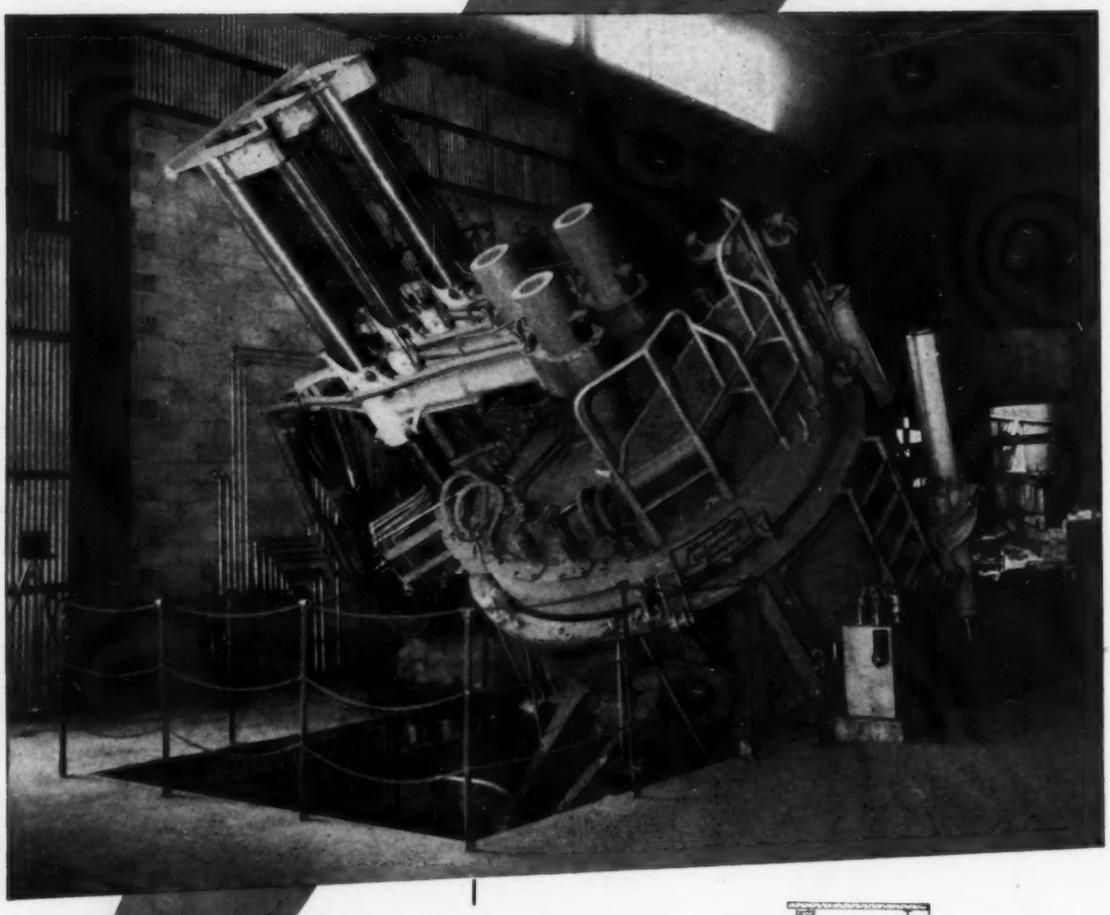

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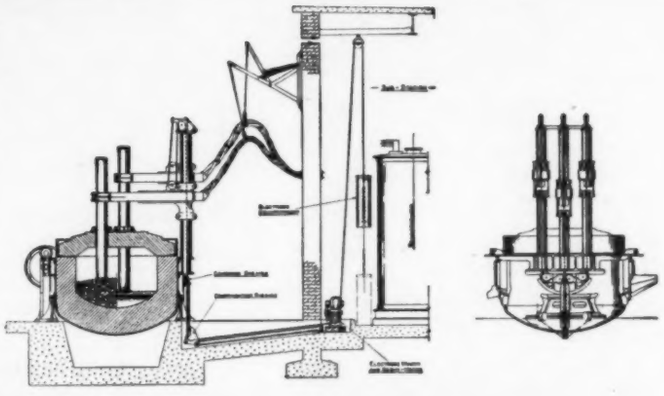

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Sponge Iron -

ITS POSSIBILITIES AND LIMITATIONS

. . . . low temperature gaseous reduction of iron ore has possibilities but requires a relatively pure ore . . . . probably not more than 1/3-1/2 of the world's ores can be economically concentrated to this purity . . . .

by C. F. Ramseyer, METALLURGICAL ENGINEER

H. A. BRASSERT AND COMPANY

NEW YORK, NEW YORK

▲ A broad survey of the subject of sponge iron shows the various processes to fall naturally into three groups: the early high temperature charcoal forge processes operating above 2000 F, the more modern medium temperature processes in which the reduction is carried out between 1600 and 2000 F, and the most recent low temperature gaseous reduction process in which the reduction takes place below 1500 F, probably between 1000 and 1100 F.

In talking about sponge iron, it is well to remember that at the present time almost all the hundred million tons of iron ore that is reduced to the metallic state in this country each year goes through the blast furnace and is made into pig iron. A small percentage of the total tonnage of ore is used in steel furnaces for refining pig iron, and a few thousand tons a year of pure oxide are reduced to iron powder for powder metallurgy. Except for this small amount of iron powder, no sponge iron is being made commercially anywhere in this country at the present time.

What do we mean by sponge iron? Generally speaking the term has come to mean almost any kind of iron made directly from ore, with the exception of pig iron made in the blast furnace. Technically it is usually defined as iron reduced to metal from the oxide without fusion. In other words, in a direct ore reduction or sponge iron process, solid particles of metallic iron are obtained directly from solid particles of ore, without any melting of either ore or iron.

I do not know exactly why sponge iron is called sponge iron, but the Roman historian, Diodorus Siculus, writing in the fourth century B.C. refers to pieces of iron stone from the island of Elba, which he said had been changed by the heat of the fire into lumps of iron resembling great sponges. These iron sponges were brought by merchants and sold to coppersmiths who worked them up into all sorts of iron tools and instruments. This seems to be the earliest mention of the term sponge as applied to iron, and it obviously refers to the porous or spongy, partially sintered mass of iron which results when iron ore is reduced in a charcoal forge fire. The spongy appearance of these early iron "sponges" was due to the fact that in a given lump of ore some of the ore melted and ran out before it was reduced, leaving holes behind in the unmelted plastic mass of freshly reduced metallic iron.

Although the direct production of iron by the forge process died out during the 19th century, the idea of producing iron directly from the ore failed to die out along with the industry. The fundamental theoretical advantages of direct reduction, i.e., the making of a finished product in one step instead of two, and the lower heat requirement of the low temperature direct process, kept alive metallurgical interest in it. This interest continued all through the 19th century and up to the present time. Hundreds of different processes have been proposed or tried and many patents have been issued on them throughout the world.

MODERN SPONGE IRON PROCESSES

The early or primitive sponge iron processes were

Presented before the Boston Section of the A. I. M. E., February 7, 1944.

relatively high temperature sponge iron processes. The group of modern processes which will be described might be called medium temperature processes, since they all are carried out in the temperature range between 1600 and 2000 F. Except for two Swedish ones, they have not been commercially successful. None of them have been able to compete with the high productive capacity and thermal efficiency of the modern blast furnace, which has proved that it can produce a tremendous tonnage of metal from a wide variety of ores at very low cost.

The older of the two successful Swedish processes is the so-called Sieurin process which has been employed at Hoganas in Sweden since about 1910. A very pure ore containing 71 per cent iron and only traces of phosphorus and sulphur is packed in tall clay pots in alternate layers with fine coal and burnt lime. The whole pot, or sagger — the operation is carried out in connection with a ceramic plant — is then brought up to a temperature of 1800-2000 F in a ring kiln. The fuel usually has been producer gas made from low grade coal. One complete cycle of heating, holding at reaction temperature, and cooling, takes from 5 to 10 days. The layers of sponge iron, which contain 96-97 per cent Fe, are removed from the pots by hand and pressed separately into standard discs about one ft in diameter and some 2 in. thick. These porous compressed discs have a specific gravity of about 5.

The other commercial Swedish process is the Wiberg process which has been in operation for the past 15 years at Sodafors. In this process purified magnetite concentrates are first sintered and then charged into a low shaft furnace, through which hot carbon monoxide is passed. About half way up the shaft three-fourths of the spent gas consisting of CO and CO_2 is withdrawn and circulated through hot coke which is electrically heated in a separate chamber. The carbon dioxide is reduced back to monoxide by contact with the hot coke, and used for further reaction with the ore. The ore is preheated by burning the un-recycled portion of the spent reducing gas with air in the upper part of the shaft. At present, the Wiberg process produces between 7000 and 8000 tons of iron per year. The Sieurin plant at Hoganas is said to produce about 15,000 tons per year.

The Germans also developed a Norwegian process called the Norsk-Staal process, somewhat similar to but more complicated than the Wiberg, which they operated for a number of years on high grade imported Swedish ore. It was reported to be technically successful and produced up to 30,000 tons of sponge iron per year, but its costs were too high to compete with ordinary steel production methods. The Germans also developed a high temperature rotary kiln process known as the Krupp-Renn process and some plants of this type are supposed to be operating at the present time in Germany on their lean high silica ores, as well as in Japan. In this process the kiln temperature is high enough not only to reduce, but also to melt both the iron and the gangue. The material leaving the kiln consists of globules of iron suspended in a molten mass of viscous high silica slag. The mixture is water granulated and crushed, and the iron recovered by magnetic concentration. The magnetic separation is not perfect, however, and the product is usually rather high in impurities.

A number of medium temperature rotary kiln installations have been built in this country. A large one designed for a capacity of 500 tons per day was put up in the late twenties at Lorain, Ohio. This was known as the Hornsey-Wills process. The United States Bureau of Mines also developed a rotary kiln process during the twenties and they have just recently placed in operation a large experimental rotary kiln plant of their design at Laramie, Wyoming. It is designed for a capacity of 50 tons of sponge iron per day. The ore and coal are charged together and heat is supplied by a natural gas flame. The reduced metallic product from the kiln is purified of gangue and coal ash by magnetic separation. A small rotary kiln is also being used commercially in at least one installation at present for the production of iron powder by the reduction of roll scale.

Another method of carrying out the reduction of iron ore in the medium temperature range below 2000 F was developed by W. H. Smith in Detroit some years ago. He carried out the reduction of a mixture of ore and carbonaceous reducing material in vertical retorts built in a battery somewhat similar to coke ovens. The temperature was held between 1600 and 2000 F. The inventor died before the plant was commercialized, and his work apparently was not carried on.

The Bureau of Mines at the present time is operating a plant in Texas designed by Julian Madaras, using reformed natural gas as the reducing agent. It is a batch process carried out at approximately 1800 F on lump ore. The hot gas is passed through the ore under a fairly high pulsating pressure which varies between 35 and 65 psi gauge. The pulsating gas pressure is said to help the otherwise slow diffusion of both the reducing and spent gases into and out of the pores of the ore. The ore stays in the reducing chamber about 16 hours after which time it is about 85 per cent reduced.

Still another process is the one developed by G. H. S. Anderson. A 100-ton unit of his design was built in Japan in the late twenties and is said to have operated successfully. In his process a layer of mixed ore and coal are heated by a muffle as they revolve on a large diameter circular hearth. The theory behind this is sound, in that the oxidizing combustion gases supplying the heat are kept away from direct contact with the ore being reduced.

FACTORS IN THE REDUCTION OF IRON ORE

These sponge iron processes, both the early high temperature charcoal forge ones and the more modern medium temperature ones, have been discussed to illustrate some of the different ways which may be used to bring about the necessary contact between reducing agent and ore at a temperature high enough so that the reducing reaction will take place. The method that gives the most direct and intimate possible contact between the reducing agent and the ore should give the best result.

In the modern processes using a solid reducing agent, the necessary contact is accomplished by mixing the ore more or less intimately with the reducing agent, usually coal. In all such cases, of course, the carbon itself does not react with the ore directly; the actual reaction which takes place is that between carbon

monoxide and iron oxide. As long as the temperature is kept above 1600 F, however, any CO_2 that is formed is immediately reduced back to CO which is then available for further reaction with the ore.

The heat required to bring the ore and reducing agent up to the temperature necessary for carrying on the reaction is variously supplied. In the early charcoal direct reduction processes, as in the blast furnace, the combustion of the excess carbon to carbon monoxide supplied the required heat. In the Sieurin process at Hoganas the heat is supplied externally by the combustion of producer gas and can only reach the ore and coal by conduction through the walls of the clay pots. This, of course, greatly limits the capacity of the process. In the Wiberg process, part of the heat is supplied electrically to the carbon monoxide gas which later gives it up by direct contact with the ore, and part is supplied by burning a portion of the spent gas in the upper part of the reducing unit, the combustion taking place in direct contact with the ore. This method gives excellent heat transfer.

In the rotary kiln processes the heat is usually supplied by a flame in the center of the kiln. This introduces a fundamental complication because it means that both the oxidizing combustion reaction to supply heat, as well as the reducing reaction to reduce the ore, have to be carried out in one and the same chamber. Maintaining two different gaseous atmospheres at the same time within a small closed space is not easy, but it can be accomplished in the rotary kiln with careful operation. The excess coal of the charge in direct contact with the ore more or less successfully maintains a reducing atmosphere around the ore granules in spite of the necessarily oxidizing atmosphere in the center of the kiln. The transfer of heat, however, is far less efficient in the rotary kiln than in a shaft furnace, because the hot gas does not pass through the ore, but merely sweeps over the surface of it. This means that for high thermal efficiency a very long kiln is required. In addition, impurities in the heating flame are likely to be picked up and become a part of the charge in the kiln. With iron ore, which tends to become sticky about 1600 F, the kiln operation has to be very carefully conducted so as to minimize the formation of rings which sharply reduce capacity. Since solid coal is frequently used not only for heat but also as the reducing agent, the impurities in it, particularly sulphur, tend to enter the metal. Although lime can control the sulphur to some extent just as in the blast furnace, its use adds to the cost of the process.

In the Smith process all the required heat had to be forced through the refractory walls of the vertical retorts and this limited the capacity which could be obtained. In the Madaras process the ore can be preheated but much of the heat is introduced in the form of sensible heat in the hot reformed natural gas used as the reducing agent. The gas is separately heated before it comes in contact with the ore. From the point of view of process design, the physical separation of two different steps having separate functions (in this case the heating step and the reducing step) so that the most suitable design of equipment can be used for each, is generally considered good practice.

The Anderson process runs into somewhat the same difficulty as the Smith process in that the amount of heat that can be transmitted to the charge through the wall of the heating muffle is small. Much more heat can always be transferred through a wall to a liquid or a gas on the other side flowing at high velocity under pressure than to a relatively stationary mass of crushed solids.

So much for the flow of heat in the different processes. Next, let us consider the flow of material. In general, the ore and carbon move downward by gravity countercurrent to the rising gases. In the early charcoal hearth processes the charge settled slowly as the charcoal was consumed by the blast, the combined combustion and reducing gases passing upwardly through it, just as in the modern blast furnace. The Wiberg process is similar, except that the charge consists solely of ore, and the gas is pure CO containing no combustion gases. In the Hoganas process, the only thing that moves while the reduction is taking place is the flue gas on the outside of the pots.

In the rotary kiln the reducing gas is generated within the charge, but escapes from it almost immediately into the flue gas stream in the center of the kiln. The reducing gases therefore do not flow countercurrent to the charge even though the charge itself is in motion continuously. The rolling motion of the charge in a kiln is valuable when a sintering or nodulizing action is desired, but this is just what we are trying to avoid in sponge iron production. In the Smith vertical retort the slow descent of the charge was partly countercurrent to the upward flow of the gas given off by the reaction. In the Madaras process only the reducing gas moves, except during the emptying and recharging of the retort with ore once every 16 to 18 hours. Anderson moves his bed of ore horizontally en masse on his rotating hearth, but this movement is not countercurrent to the gas.

Summing up we see that in these different processes we have the ore descending vertically, moving horizontally, rolling spirally or not moving at all, and also that the ore may be in direct contact or out of direct contact with the combustion gases. What is the best method of operation?

One way of settling this question is by the criterion of commercial success. The only processes which so far have been able to operate and stay in business have been the two Swedish processes, the Hoganas and the Wiberg. It is obvious from the description of the Hoganas process that its success is not due to its high capacity and low operating cost. It has been successful in spite of its high cost because of the high quality and purity of its product, and this is due both to the purity of the ore and the operating practice.

Due to its high labor cost and low capacity, I think we can safely dismiss the Hoganas process from consideration for large scale world wide use. This leaves the Wiberg process as the only remaining process in successful operation at present. The Wiberg is a well thought out process. The reduction is carried out in a shaft furnace which gives excellent contact between the sinter and gas, and the reducing gas is high in reducing power since it contains no inert products of combustion. The preheating of the ore is also done in the same shaft by direct contact with the burning gas, a most efficient method of heating.

The Wiberg process, however, has three fundamental disadvantages. First, it cannot use the fine concentrates

just as they come from the magnetic separator. They must first be sintered into lumps large enough for use in the shaft furnace. This sintering adds to the cost. Second, since carbon monoxide is used, a temperature around 1700 F has to be maintained to get a reasonably rapid rate of reduction and also to avoid decomposition of the CO into C and CO_2 by the so-called carbon disposition reaction which begins to take place at temperatures below 1600 F. The third disadvantage is that the carbon dioxide must be passed through hot coke to regenerate CO and the heating of the coke is expensive. In Sweden, where electric power is very cheap, this is done electrically, but it conceivably could be done by an intermittent water gas type of process. Hot carbon decomposes CO much less rapidly than steam, however, so that larger equipment than that used in ordinary water gas practice would be required.

Summarizing, the three disadvantages of the Wiberg process are that only lump ore or sinter can be used, the operation has to be carried out at such a high temperature that sticking difficulties are encountered, and finally, the regeneration of CO_2 to CO is not very satisfactory. All these items influence cost and capacity.

USE OF FINE ORE

The use of fine ore in a shaft furnace requires coke to give porosity to the stock column. If coke is not charged, only lump ore can be used. This brings us to a factor which is fundamental for any reaction between a solid and a gas, such as the gaseous reduction of iron ore, that is, the amount of solid surface exposed. In any chemical reaction between a gas and a solid the smaller the particle size, the greater the area exposed to the action of the gas. A good illustration is the combustion of pulverized coal; by fine grinding it is possible to do practically everything with powdered coal that can be done with oil or gas. It would be highly desirable in the reduction of iron ore if some method could be worked out to take advantage of the easy reducibility of iron oxide in the finely divided condition.

In all the processes in which gas passes directly through the ore, whether a blast furnace, the Wiberg shaft or the Madaras reducing chamber, lump ore is required to provide a gas passageway and to ensure the even descent of the charge. While it is true that the rotary kiln can use somewhat finer material than the shaft furnace, the Bureau of Mines in its experiments on the reduction of iron ore with gas found it best to keep the kiln charge coarser than 35 mesh. This was due to the imperviousness to gas penetration of finer materials, to the greater dust loss, and in addition, to increased sintering and sticking difficulties, since the work was largely in the temperature range above 1400 F. Even when using solid carbon in the rotary kiln, the advantage of the continuous countercurrent contact between ore and gas that occurs in the shaft furnace is largely lost, since the gas escapes from the ore and joins the combustion gases practically as fast as it is generated, giving only a brief period of contact between the gas and the ore.

Of all the processes discussed, only the Hoganas and Anderson processes can use finely divided ore. The capacity of both of these processes, however, is limited by the relatively small quantity of heat which can be transmitted to a bed or charge of ore through the refractory walls of either the Hoganas pots or the Anderson muffle.

USE OF GAS UNDER PRESSURE

A further way of increasing the rate of reaction, in addition to fine grinding, would be to make a greater number of gas molecules available to react with the increased surface area. This can be done by putting the gas under pressure. A process designed to carry out the reduction of ore, particularly finely divided ore, with gas under high pressure, would have great advantages.

There are at least five good reasons for using gas under pressure. The first, we have just mentioned, i.e., increasing the rate of reaction.

Second, the heat capacity of the gas per unit volume would be greatly increased. Since the heating of the ore, the endothermic heat of reaction, and the radiation loss from the equipment all have to be supplied by the sensible heat of the hot incoming reducing gas, its volumetric heat capacity is very important.

Third, by using very high pressure, the volume of gas that has to be handled is greatly reduced, and both the size of the gas handling equipment and the cost of recycling the gas become very much smaller.

Fourth, since much smaller actual gas volumes will be required, higher pressure drops with consequent higher gas velocities through the heat transfer equipment can be used economically. The higher gas velocities in turn will greatly increase the rate of heat transfer, and thus still further decrease the size of the heat exchange units.

Fifth, after passing up through the bed of ore the very much smaller volume of gas will leave the surface of the bed at such a low velocity that the dust loss will be negligible. The low velocity of the gas through the ore will also give more time for completion of the reaction between the gas and the ore. On the other hand, the higher pressure will still make it possible to put enough gas (by weight) through the ore so that capacity will not be adversely affected.

The next question is what reducing gas to use. Carbon monoxide cannot be used under high pressure in the low temperature range we are interested in, since in accordance with Le Chatelier's principle, pressure throws the reaction $2CO = C + CO_2$ to the right. This reaction would not only destroy the reducing power of the gas, but the equipment would plug up with carbon black.

HYDROGEN AS A REDUCING GAS

This means that, if we are to operate at high pressure in this temperature range, we must use some other gaseous reducing agent than carbon monoxide. The only other economic possibility is hydrogen. Pressure has little or no effect on the equilibrium of the reaction between iron oxide and hydrogen, since no change in volume is involved; one molecule of hydrogen forms one molecule of water vapor.

Is there any information available on the reduction of iron oxide by hydrogen? The answer is yes. There is quite a lot of information available on this subject

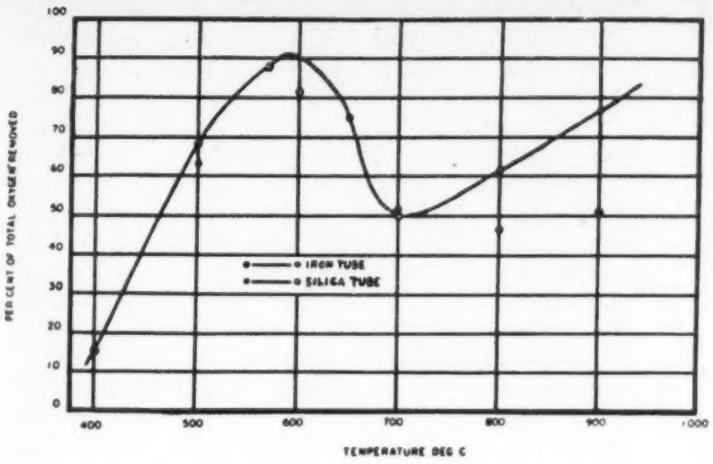


Figure 1 — Temperature-reduction curve for an eastern magnetite ore, showing maximum rate of reduction to occur at about 600 C (1100 F).

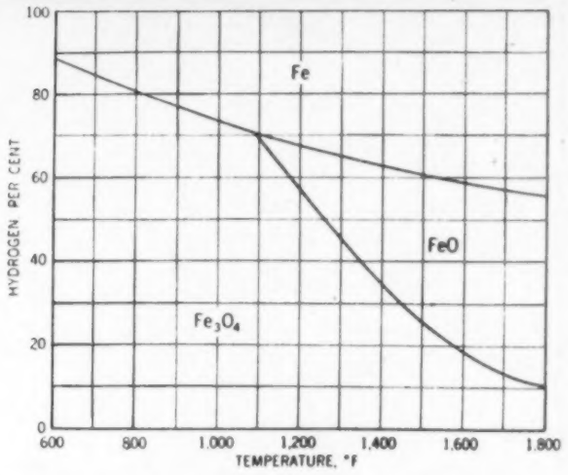


Figure 2 — Equilibrium diagram of iron oxide-hydrogen-water vapor system.

since iron catalysts have been used in chemical industry for many years. They have commonly been made by reducing iron oxide at very low temperatures — as low as 570-750 F. In fact, the lower the temperature at which the reduction is carried out, the more active the catalyst usually is.

The main reason that pure hydrogen — that is to say, commercially pure 95-97 per cent hydrogen — has never been given much consideration as a reducing agent for iron ore on a steel plant scale is probably because hydrogen has always been thought of as a very high priced material, good for laboratory use, but entirely too expensive to compete with carbon and carbonaceous reducing gases industrially. This was undoubtedly true in the past, but today when hydrogen is produced on a tremendous scale for making synthetic ammonia and for hydrogenating coal and oil, this is no longer true.

Let us compare hydrogen with carbon as a reducing agent. In the blast furnace it takes roughly one pound mol of carbon (12 lb) to remove one pound atom (16 lb) of oxygen from iron ore. This is because the carbon in the reducing reaction first has to be partially oxidized to carbon monoxide before it can act on the ore. On the assumption that the heat of oxidation of the carbon to carbon monoxide supplies the heat required, while the carbon monoxide itself supplies the reducing effect, one mol of hydrogen may be said to have about the same reducing power as one mol of carbon, or one pound of hydrogen six times the reducing power of one pound of carbon. Comparing hydrogen directly with carbon monoxide the figure is still higher — fourteen to one.

The use of hydrogen has one very great advantage; it makes possible operation at very low temperatures — temperatures so low in fact that the sticking and sintering difficulties which always occur when iron oxide in the finely divided state is reduced at temperatures above 1200-1400 F are completely avoided. The industrial possibilities inherent in the fact that hydrogen can reduce iron ore at temperatures between 1000 and 1100 F have been little appreciated until recently.

Complete data on the rate of reduction of an eastern magnetite ore at various temperatures were given in a paper by Udy and Lorig presented before the A. I. M. E. a year ago. Figure 1 is a curve taken from this paper, the original data for which was obtained at the Battelle Memorial Institute in connection with some work done on the gaseous reduction of ore for H. A. Brassert. This curve shows that the maximum rate of reduction of the particular magnetite studied occurred at approximately 1100 F. At this temperature 90 per cent of the oxygen was removed from the ore in the short time of 20 minutes. Moreover, the ore used was relatively coarse, about the size of coarse sand, or between 28 and 35 mesh. The results shown by the curve were obtained by passing hydrogen continuously through a ½ in. thick bed of the ore. The maximum rate of reduction was attained at a gas velocity somewhat below 2 fps. This velocity apparently supplied all the fresh hydrogen that the ore was capable of reacting with under the given conditions; higher velocities did not increase the rate of reduction. The limiting factor was probably the rate of diffusion of the water vapor formed by the reaction out from the protected center of the ore particles.

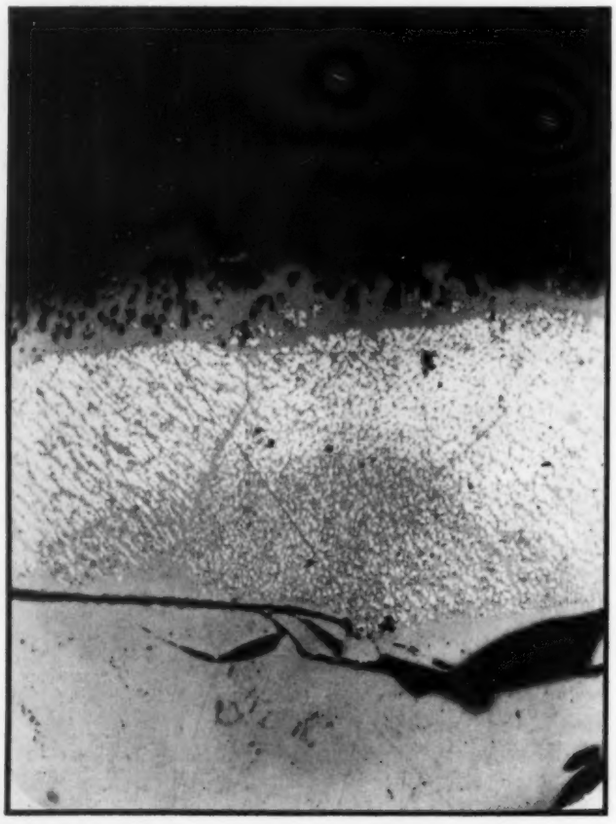
Figure 2 shows an equilibrium diagram of the system iron oxide — hydrogen-water vapor, which I believe helps explain the reason for the 1100 F maximum in the rate of reaction curve just shown on the previous slide. We think that the rapidity of the reaction in the temperature range to the left of the 1100 F triple point is due to the fact that the magnetite reduces directly to metallic iron without the formation of any interfering third phase, while above 1100 F the rate of reduction is greatly retarded because of the formation of FeO, which is known to be hard to reduce. At 1100 F the gas concentration at equilibrium is 30 per cent water vapor and 70 per cent hydrogen.

Figures 3 and 4 are photo-micrographs made by A. T. Cape on single crystals of magnetite reduced at two different temperatures, one below 1100 F and one above 1200 F. Figure 3 shows the low temperature reduction and you will notice that the whole upper portion of the magnetite grain has been reduced to metallic iron, un-

Figure 3 — Photo-micrograph made on single crystals of magnetite reduced at 1080 F.

▲

Figure 4 — Photo-micrograph made on single crystals of magnetite reduced at 1200 F.



reduced magnetite appearing only at the lower half of the figure. There is no transition between the two phases. The reduced iron field meets that of the unreduced magnetite at a sharply defined, although irregular, boundary line.

In Figure 4, where the reduction temperature was above 1200 F, you will notice that no portion of the field has been completely reduced to metallic iron but instead, there is an inter-mixed two-phase area showing small, partly reduced and unreduced phases. This mixed, finely divided field appeared because the reduction was carried out at a temperature to the right of the triple point in the equilibrium diagram, so that some of the ferrous oxide phase formed. The reduction of ferrous oxide by hydrogen is quite slow and difficult, apparently much more difficult than the reduction of magnetite itself. The appearance of the FeO phase during reductions seems to change the structure of the ore so that the water vapor formed is no longer able to make its way easily out from the interior of the particle.

DESIGN FACTORS

The Brassert process, so far as the writer knows, is the only one expressly designed to make use of the reducing power of hydrogen between 1000 and 1100 F. Before discussing this process in detail, however, it might be well to explore the mechanism of the reaction a bit further and bring out a few additional facts of importance for the commercial reduction of iron ore at these very low temperatures.

When pieces of iron ore are reduced by hydrogen gas below 1400 to 1500 F, they retain exactly the same size and shape after reduction as they had before. Only the oxygen is removed. As a result, the density of the freshly reduced iron particles is less than that of the ore from which they have been made. Such particles of reduced ore come under our definition of the term sponge iron. Although they neither appear nor behave as if they were spongy, they must contain voids in place of the oxygen, since their bulk density is less than that of the ore from which they have been reduced. The holes or pores left in the structure of the ore after the removal of the oxygen, however, are too fine to be resolved by the highest powered optical microscope. If someone can take a picture of these holes some day with the aid of the electron microscope, we may get a better understanding of the actual mechanism of the reduction reaction.

From our own experimental work we have found that when powdered iron oxide, which is very loose, fluffy and active when hot and permeated with hydrogen, becomes almost completely reduced, the fine, nearly pure metallic particles tend to sinter or knit together ever so slightly, forming a very lightly bound, immobile, porous bed, even at temperatures as low as 1300 or 1200 F. This fact has also been observed in the laboratory by other experimenters and reported in the literature. By staying below 1100 F, however, this effect is completely avoided and the finely divided reduced iron particles show no sintering action whatsoever. This is of very great importance from the point of view of process design, because it offers us, for the first time, the possibility of handling finely divided iron ore with-

out having to worry about any building up of material in the equipment. Furthermore, it does away with any need of using high temperature refractory construction for carrying out the reduction. Equipment made of the relatively inexpensive lower alloy heat resisting steels is perfectly suitable for use up to 1300 F.

About the only thing we have to worry about in this gaseous reduction of iron oxide at very low temperature is the fact that the resultant finely divided, freshly reduced iron is an extremely reactive material. Apparently the microscopic and sub-microscopic pores in the metallic particles have such an extremely large surface area that they are highly pyrophoric; that is, they will sometimes catch on fire spontaneously when exposed to air even though they have been cooled down to room temperature in a reducing or inert atmosphere.

COKE OVEN GAS AS SOURCE OF HYDROGEN

If we want to reduce ore by the low temperature gaseous reduction process how can we employ the various facts which have just been brought out to the best advantage in the choice of equipment? This will depend in the first place on the source of the hydrogen gas which is to be used. A hydrogen gas low in carbon monoxide is desirable because of the carbon deposition reaction which takes place just in this temperature range in a high CO gas. This restriction narrows the list of industrial gases with a sufficiently high hydrogen content and a sufficiently low CO content either to coke oven gas or to commercial hydrogen made from coke, natural gas or petroleum products. We have therefore developed two distinct types of plants for carrying out the Brassert process; the first type of plant is that now being built at the Warren, Ohio, plant of Republic Steel Corporation for the Defense Plant Corporation. This is designed to make use of a part of the hydrogen content of coke oven gas.

Coke oven gas at present in the plants of the large integrated steel companies is used mainly as a fuel. The hydrogen in it, therefore, if it can be utilized without separating it from the gas, is extremely cheap compared with the cost of hydrogen produced by any known process, with the possible exception of that made by the thermal cracking of very cheap natural gas. The production of one ton of sponge iron takes roughly 16,000 cu ft of pure hydrogen for the 90-95 per cent reduced product desired by the electric steel furnace metallurgists as a melting stock; 16,000 cu ft of hydrogen has a fuel value of 5,250,000 Btu. Assuming that coke oven gas is available at approximately 20¢ per million Btu, which is about its normal value in the steel industry, the cost of the entire reducing agent for producing one ton of sponge iron from ore is only 5¼ times 20¢ or $1.05 per ton. This, then, forms the economic basis for our proposed use of coke oven gas for reducing iron ore.

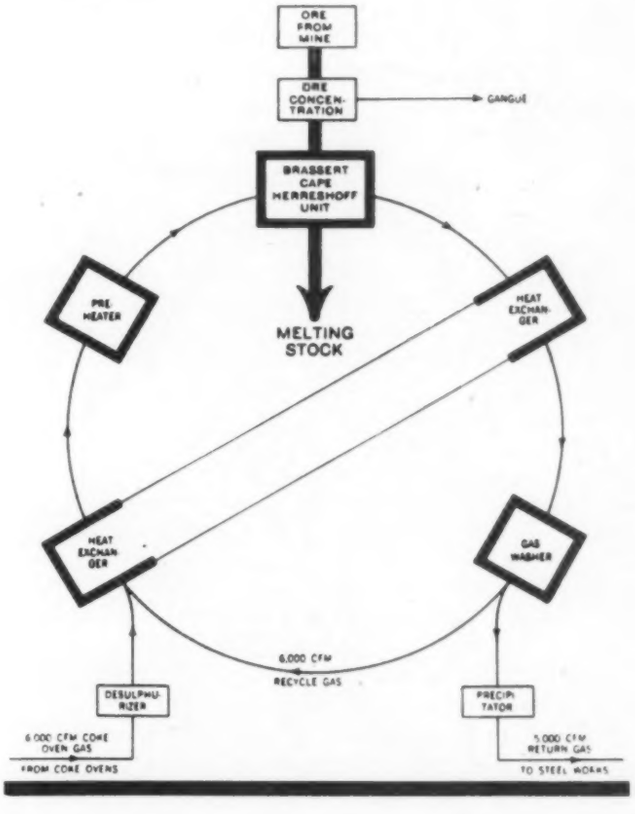
The Warren installation is designed to use coke oven gas, and for this plant WPB quite properly insisted, to save experimental delay in the war emergency, that only standard proven types of equipment should be used. This rule was adhered to in initial proposals, and the plant as it is now being constructed closely follows in all essentials the details of the process as originally laid out, although in a few cases the types of equipment originally proposed had to be changed due to war demands and the inability of manufacturers to meet specifications.

In the design of the Warren plant we had to take into consideration the fact that coke oven gas contains 6-7 per cent carbon monoxide, as well as 2-3 per cent of unsaturated hydrocarbons, either or both of which have a tendency to decompose if heated. Also, as brought out earlier, pressure greatly increases this tendency to decomposition, particularly in the case of carbon monoxide, so any kind of a high pressure operation had to be avoided. In addition, the coke oven gas distribution system, as in most steel plants, operates at a relatively low pressure, between 5 and 10 psi. A further factor was that only about ⅓ of the hydrogen content of the coke oven gas can be utilized in the reaction due to the equilibria involved. One-third of the hydrogen content amounts to only about one-sixth of the total volume of coke oven gas handled, so it would hardly be worth while to compress all the gas to high pressure in order to use only one-sixth of it. The Warren plant, therefore, is designed to operate at only slightly above atmospheric pressure, the maximum pressure being about one psi.

THE HERRESHOFF FURNACE WITH BOTTOM SLOTTED HEARTH

Figure 5 shows a flow sheet of the process. The coke oven gas at Warren, as it comes from the coke oven

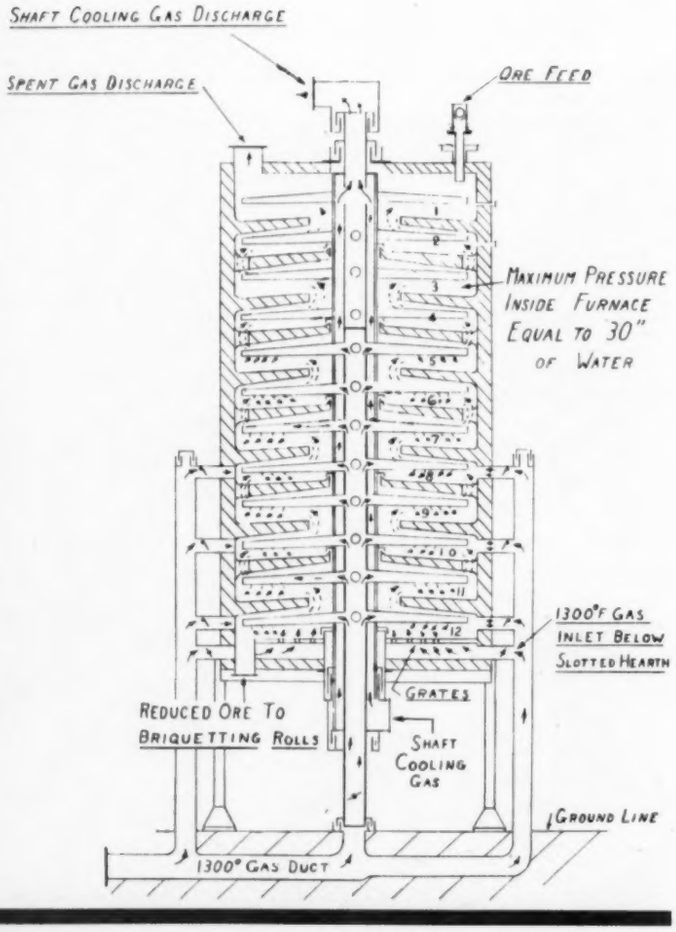
Figure 5 — Flow sheet of a low temperature gaseous reduction process.



plant, is already desulphurized below 50 grains of sulphur per 100 cu ft. Since finely divided, freshly reduced iron oxide has a very great affinity for sulphur, however, the gas must be further desulphurized to below nine grains per 100 cu ft. This is done in ordinary gas house iron oxide purification boxes. The desulphurized gas, together with an equal volume of clean recycled gas, is next heated up to 600 or 700 F in a heat exchanger by the sensible heat of the hot spent gas leaving the reducing unit. Its temperature is then further raised to 1200 to 1300 F in a separately fired gas heater, after which the hot gas goes to the Herreshoff furnace. This unit was chosen as the best standard commercial piece of equipment for preheating and partially reducing the ore.

Figure 6 shows a vertical section through the Herreshoff furnace. In order to get maximum flexibility in this first installation, the unit has been designed so that the hot reducing gas can be admitted to it in three different ways: through side ports above three of the lower hearths, through orifices in the lower hollow rabble arms, and directly up through the ore on the bottom hearth. The latter is of a slotted hearth design developed over a long period of experimentation during which it was found possible to make fine ore flow like a liquid, without the use of any mechanical means, by bubbling hot gas up through it. This lower slotted hearth furnishes the direct and intimate contact between partially reduced ore and the fresh incoming gas required to complete the reduction. The temperature of the various hearths may be controlled by varying the relative amounts of gas admitted to the furnace in these three ways.

Figure 6 — Vertical section through the Herreshoff furnace.



The entire volume of fresh coke oven gas, augmented by a like volume of dry, recycled gas, goes through the Herreshoff. The gas zig-zags in and out over each hearth, counter-current to the ore, which similarly moves out and in over each hearth, dropping downward through drop holes at the center and the periphery of every other hearth. The total volume of gas handled per minute per ton of productive capacity is roughly equal to that in a blast furnace. The pressure, however, is lower.

The ore at Warren is expected to be an Adirondack magnetite concentrate, all minus 10 mesh, with between 10 and 20 per cent of minus 200 mesh material. A flue dust loss up to possibly 5 per cent of the ore charged is therefore anticipated. Unlike the blast furnace, there will be no possibility of the charge hanging or slipping since the depth of the ore moved on the hearths by the rabble arms is only about 2 in. The ore will remain in the furnace in contact with the hot coke oven gas from 8 to 12 hours. Based on the Bureau of Mines experiments with a small rotary kiln at Mococo, California, using reformed natural gas containing only about one-half the hydrogen content of coke oven gas, this should be sufficient for the projected capacity of 100 tons a day. The hot spent gas is expected to leave the furnace at a temperature between 900 and 1100 F.

From the heat exchanger it goes to a gas washer where it is partially cleaned and the water vapor formed in the reaction condensed out, and then to an electric precipitator where it is completely cleaned. Slightly more than half of the clean gas is recycled through the system, the rest being returned to the steel works gas system for fuel use. It is difficult to get good gas-to-gas heat transfer at the low pressure and pressure drops more or less inherent in an atmospheric pressure operation. Due to this and the fact that the gas contains only 50 per cent hydrogen, the size of the equipment is relatively large. The Herreshoff furnace itself is the largest unit, being about 45 feet high and 20 feet in diameter. The combined volume of the heat exchanger and heater is roughly one-third that of the Herreshoff.

The pyrophoric nature of sponge iron particles reduced at these low temperatures has been previously mentioned. To avoid reoxidation of the product and also to put it in a form suitable for use as a steel furnace melting stock, the hot reduced fines, just as they come from the outlet of the furnace and while still in the hot reducing coke oven gas atmosphere, feed directly down into a water cooled roll type briquette press. This press is designed to produce corrugated slabs of compressed sponge iron 5½ in. wide by 7½ in. long and about ¾ in. thick. We expect them to have a density of between 5 and 6.

So much for the Warren plant, the design of which is based on using part of the hydrogen in coke oven gas as the ore reducing agent. Its economic justification, as before stated, aside from the great superiority of the product over pig iron, particularly as an electric steel furnace melting stock, is due to the low cost of the

hydrogen content of coke oven gas on a Btu basis. In this type of plant the reducing gas is heated in a separate gas heater and the Herreshoff furnace is used solely for obtaining contact between the gas and the ore, first to preheat it and then to partially reduce it, the final reduction taking place on the bottom slotted bubbling hearth. Some increase in efficiency could undoubtedly be gained by preheating the ore in some kind of external heater before feeding it to the reducing unit. This would probably be justified for a larger capacity unit.

PRODUCTION AND USE OF PURE HYDROGEN

Let us next consider the type of equipment proposed for use for plants operating on commercially pure hydrogen rather than on coke oven gas. In this type of plant we are not limited by the presence of CO, so we can use very high pressure and finely divided ore, 60 mesh or finer.

The first question is the production of the hydrogen. There are many possibilities. It can be obtained from natural gas either by cracking at high temperature into carbon and hydrogen, or by reforming with steam to carbon monoxide and hydrogen, with subsequent conversion of the carbon monoxide with additional steam over a catalyst, to hydrogen and carbon dioxide. This gas mixture can then be compressed and the CO_2 scrubbed out with cold water, leaving a 95-97 per cent hydrogen gas available under high pressure for the ore reducing unit. The same process can be applied to blue water gas, a mixture of hydrogen and carbon monoxide produced from coke. Depending upon the price of the basic fuel used, i.e., whether it is natural gas, petroleum products, or coke, hydrogen can be made for from 12¢ to 40¢ per 1000 cu ft, including fixed charges.

If hydrogen is recycled in a so-called "dead-end" or closed cycle system the inert impurities in the gas tend to build up and have to be eliminated by bleeding. As a result approximately 20,000 cu ft of commercial hydrogen are required per ton of sponge iron produced, instead of the 16,000 cu ft theoretical figure. Where electricity is very cheap, that is, 1½ mills per kwhr or less, electrolytic hydrogen can be used economically. On the assumption that hydrogen is available, the next question is how to get the best possible contact between it and the ore.

THE BUBBLE CAP ORE REDUCTION FURNACE OR COLUMN

Figure 7 shows the type of reducing unit proposed for this purpose. The essential part of it is a flat circular hollow hearth made of alloy steel which is supplied with hot hydrogen gas under pressure. The surface of the hearth is dotted all over with small hydrogen inlets called bubble caps, since they are somewhat similar to the bubble caps on the plates of the fractionating towers used by the petroleum industry. These bubble caps contain a number of very small holes. When a bed of minus 60 mesh ore (it should contain as little minus 400 mesh material as possible) is placed on a hearth of this type to a depth of between 6 in. and 20 in. and hot hydrogen is bubbled through it, the mass of ore behaves exactly like a liquid and will flow around channels and from one hearth to another, due to gravity, just as if it were liquid. By keeping the temperature below 1100 F the ore remains completely fluid even after it has been practically 100 per cent reduced. It should be emphasized that this type of design is possible solely because of the low temperature range between 1000 and 1100 F that is used, and the low temperature is possible only by the use of hydrogen.

This type of hearth can handle fine ores because the velocity of the gas necessary to fluidize the ore is very low, less than $^1/_{10}$ fps being required. This is but $^1/_{100}$ of the velocity of the gas leaving the top of a blast furnace. Proper fluidization of the ore, however, requires a very uniform distribution of gas over the whole hearth area. This is achieved by making the total area of all the fine gas orifices in the bubble caps small compared to size of the gas supply line to the hollow hearth and by maintaining a pressure drop of from 2 to 5 psi through the bubble caps; that is, the gas pressure in the hollow hearth is kept 2 to 5 psi above the pressure over the ore bed. Practically the whole of this pressure drop occurs through the caps. This pressure drop, of course, adds to the power required to recycle the gas, and so represents the price that must be paid to get proper uniformity of gas distribution.

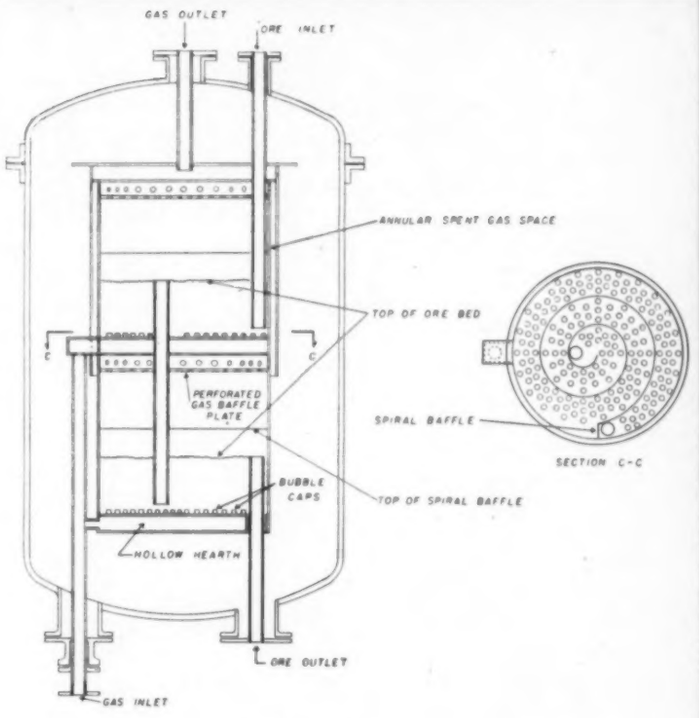


Figure 7 — Type of reducing unit proposed for low temperature reduction with hydrogen.

COMPARISON WITH BLAST FURNACE PRACTICE

Table I shows some of the operating characteristics of a blast furnace compared with estimated figures for the hollow hearth bubble cap type of furnace.

TABLE I

COMPARATIVE DATA—BLAST FURNACE VS BUBBLE CAP FURNACE

	Blast furnace	*Bubble cap furnace*
Size of ore	Crushed—6 in.	—60 mesh
Time in furnace, hr	12	½
Volume of gas handled, cu ft per ton	120,000	160,000
Per cent reducing gas	30	85
Gas pressure, psi	20	450
Temperature, F	3000	1100
Velocity of gas leaving ore bed, fps	10	0.1
Product	Molten pig iron	Sponge iron slabs or briquettes

Ratio of partial pressure of H_2 (bubble cap furnace) to partial pressure of CO (blast furnace) is 60 to 1.

This furnace is designed particularly for carrying out the reduction of powdered iron ore to sponge iron with hydrogen. Since the ore should be minus 60 mesh or finer, the product of ore benefication processes can be utilized without sintering. The residence time of the ore in the furnace is much lower than in the blast furnace, due to (1) the high partial pressure of the reducing gas, (2) the fineness of the ore, and (3) the perfect mixture and intimate contact between ore particles and gas. Note that the ratio of the partial pressure of hydrogen in the bubble cap furnace to that of carbon monoxide in the blast furnace is 60:1. This fact, coupled with the fine state of sub-division of the ore (a 60 mesh particle has less than one two-hundredth the volume of a 10 mesh particle), explains why a residence time of only one to two hours is needed.

The capacity of this type of reducing equipment is believed to be limited solely by the amount of hydrogen we can put through the fine ore without incurring an uneconomical dust loss. At .1 fps the dust loss will be exceedingly small with the uniform gas flow given by the design. The gas from each hearth only passes through the ore once. It is drawn off continuously at the periphery of the hearth into an annular cylindrical space between the hearths and the furnace lining. The gas from this annular space can be withdrawn at any point convenient for connection to the heat exchanger.

A few capacity calculations may be of interest. If we assume a gas velocity at the actual temperature and pressure in the furnace of .1 fps, then one sq ft of hearth area will pass about 8500 cu ft of gas per day. Let us further assume that only 10 per cent of this hydrogen reacts with the ore to form water vapor. This is a very conservative assumption since the equilibrium is 30 per cent and, in a deep bed of fine ore at the low velocity of .1 fps, it is quite likely that equilibrium will be very nearly reached; 10 per cent means that our capacity is limited to 850 cu ft of hydrogen per sq ft of hearth area per day. However, at 450 psi pressure, we have 30 times the amount of gas per cu ft that we have at atmospheric pressure. The temperature, on the other hand, on the absolute scale, is approximately three times room temperature, so the 30 must be divided by three, giving a net ten-fold increase. The volume of hydrogen reacted per sq ft of hearth area per day will therefore amount to 8500 standard cu ft, or sufficient to produce about one-half ton of sponge iron per sq ft of hearth area per day. In other words, a single bubble cap hollow hearth section 8 ft in diameter, (which would require a 10½ to 11 ft shell) will produce 25 tons of sponge iron per day.

If 20 of these hearths are placed one above another three feet apart, a 60 ft high furnace unit will have a capacity of 500 tons per day. The internal volume of such a unit would be 3000 cu ft or approximately 1/10 that of a 1000 ton blast furnace. (It should be remembered that ⅔ of the blast furnace volume is taken up by coke.) Based on this a bubble cap unit may be said to have a productive capacity per unit volume at least five times greater than that of a standard blast furnace. This, as stated before, is due to the fact that the reducing gas used contains a high percentage (85 per cent) of the reducing agent (hydrogen) under far higher pressure than the blast furnace, and the ore is much more finely divided. It naturally will react and be reduced much more rapidly therefore than in a blast furnace. Udy and Lorig's data bears this out also. In their work they had to pass fresh H_2 through a ½ in. stationary bed of ore at velocities over 2 fps before the rate of H_2 supply ceased to affect the rate of reduction. We will operate with much finer ore, with a bed 20 times as thick, and at $^1/_{20}$ of their 2 fps velocity. Hence the conclusion that the rate of supply of hydrogen to the ore is the only factor limiting the capacity.

In connection with the production of hydrogen, Table II shows the percentage of the heating value in coke or anthracite coal which can be converted into gas.

TABLE II

THERMAL EFFICIENCY OF THE CONVERSION OF COKE TO SOME INDUSTRIAL GASES

	Per cent
Hot producer gas	93
Cold producer gas	88
Blue water gas	68
Hydrogen	45-55

It will be noticed that the most efficient conversion is that to hot producer gas. If this gas is cooled for handling by fans and compressors, the efficiency shrinks to 88 per cent. In intermittent blue water gas practice, the efficiency is still further reduced to 68 per cent. The further conversion of blue water gas into hydrogen catalytically with steam brings the overall figure down to around 50 per cent.

However, by careful design it should be possible to raise this efficiency to 55 per cent, and eventually it should be possible to boost it to at least 60 per cent. This is purely a matter of refinement and simplification of design in an art that at best is still relatively in its infancy.

CONCLUSION

It will now be obvious that the main item of cost, other than the cost of ore, of this newest version of the low temperature gaseous reduction process just described is the cost of hydrogen. Under present practice with $5.00 coke, hydrogen can be produced for around

(*Please turn to page 72*)

Dust Collecting Systems

. . . . summarizing recommended practices in the design and operation of dust collecting systems as applied to grinders, tumbling mills, sandblast equipment, mixers, crushers, etc. . . . .

by F. C. Morey

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▲ IT has been only in comparatively recent years that much study has been given to dust collecting and exhaust systems, and that any definite rules, recommendations, and codes have been set up to cover their design, operation, and maintenance. It is the purpose of this article to summarize and point out some of the good practices that should be followed, and much of the data given was taken from state and association codes and handbooks, which are, of course, more elaborate in their details.

Years ago, a dust collecting system was installed as a necessary evil and quite often was forgotten as long as it ran in a fairly satisfactory manner. I am reminded of the time, some twelve years ago, when we were asked to quote on a dust collecting system for some grinders in a western Pennsylvania plant. In this plant there were two separate grinder departments, one of which, on the second floor, was equipped with hoods, piping, cyclone collector, and fan, while the one on the first floor was not. Even in those days the workmen were familiar with silicosis hazards, and the grinder operators all were quite insistent on working at the machines on the second floor because of the much healthier conditions found there. The two departments were exactly alike in the number of machines and arrangement, and we were told to figure on a duplicate system for the first floor. However, on inspecting the second floor system, it was found that the design of the hoods, piping, fan, etc. was entirely inadequate, and as a consequence many of the connections were filled with dust and very little, if any, air was being exhausted through this system. In other words, the mere psychology of having a blow-pipe system installed satisfied the workmen, which is a condition which does not get by these days; ordinarily sufficient suction must be provided to practically pull a man's hat off before he is happy.

Any dust collecting system starts, of course, at the dust source with the proper method of controlling the dust so it is carried away by the air stream. Many kinds of equipment, such as grinders, buffing wheels, etc., are provided with hoods, built in accordance with codes and having the proper size of exhaust connections. These hoods have been developed from years of experience, are adaptable to the job and are extremely effective in controlling the dust. Figure 1 shows a typical arrangement of grinder hoods and piping.

Other equipment, such as tumbling mills, sandblast equipment, mixers, and crushers, are relatively easy to

Figure 1 — Typical arrangement of hoods and piping on grinders.

Presented before A. I. S. E. Cleveland-Youngstown District Sec. Meeting, April 17-18, '44

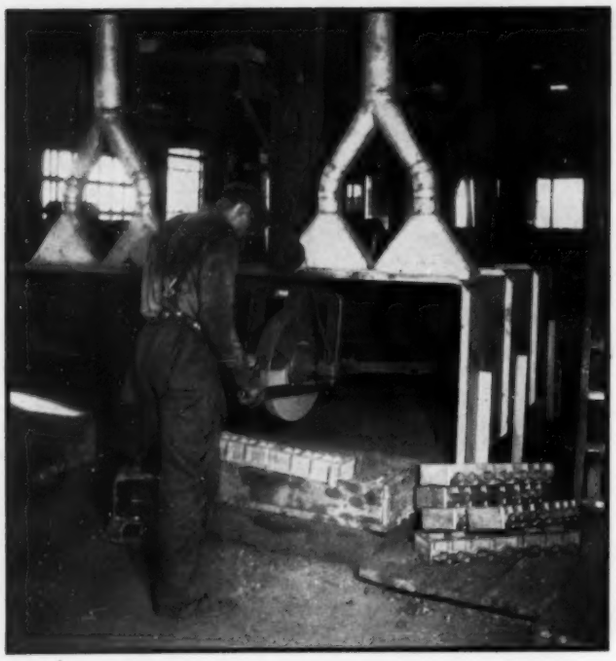

Figure 2 — Example of hood designed to catch particles thrown by action of the grinding wheel.

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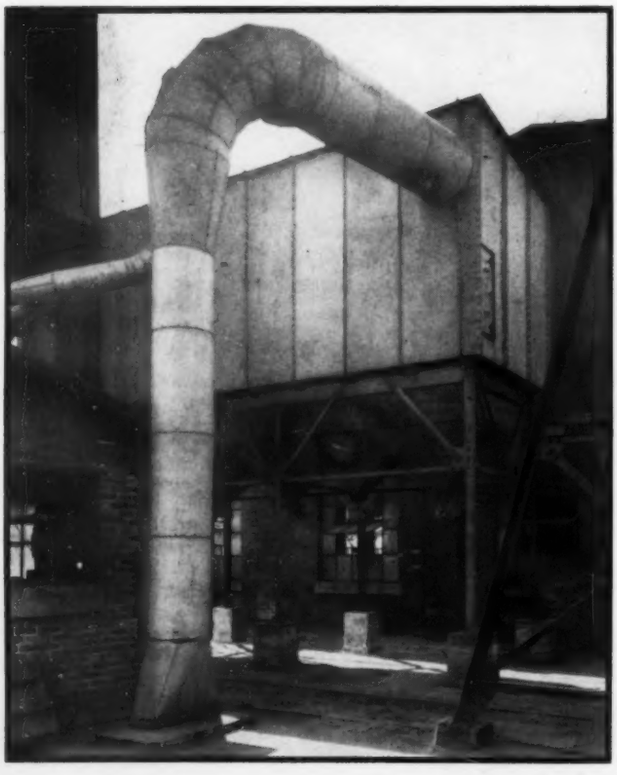
Figure 3 — Various types of fittings are illustrated in this galvanized piping system.



exhaust, as the dust producing process is enclosed and it is only necessary to keep such equipment under a negative pressure to prevent the dust from escaping to the general atmosphere. Consideration must of course be given to the necessity of providing an inlet for air into the equipment, and these inlet areas should be equal to or greater than the exhaust area.

Processes which can be only partially enclosed, or where a hood is placed adjacent to the dust source, require the most study from a design standpoint. Ordinarily, most codes specify that the velocity through the opening in a partial enclosure be not less than 100 fpm and this figure may go as high as 300 fpm, depending on the process and type of dust. It can readily be seen that the smaller the opening, the less air that must be handled, and consequently, the less costly the dust collecting equipment and its operation. The most effective way of enclosing a process often has to be studied in cooperation with the production department to insure unhindered operation, accessibility to controls, ease of maintenance and many other factors, and often experimental hoods and enclosures are made before the final design is evolved.

If operations cannot be performed in a total or partial enclosure, it is necessary to provide a hood as close as practicable to the dust source. In designing a hood of this type, it must be remembered that air tends to flow toward the hood from all directions, and the general effect is of a spheroid of air moving constantly into the hood opening. The velocity of the air flowing into the hood decreases very rapidly away from the hood face; hence it is very important that the hood be placed as close as possible to the point to be exhausted. If the operation is such that the dust particles are thrown, the hood may be placed in such a way as to catch these particles, thereby requiring less hood mouth velocity. Figure 2 is an example of such a hood.

Another factor which must be taken into account in designing such hoods is air currents from outside sources which might affect the flow of dust; if such air currents do not aid the flow of dust toward the hood, baffles should be used to control such currents. It can therefore be seen that where no code is set up, or no specific set of data is available for controlling a dust source, the designer must use ingenuity in the design of the hood, or if necessary, conduct experiments on various shapes and sizes of hoods in order to recommend an economical exhaust system.

PIPING

The size of the pipe connected to standard hoods is given in many state and association codes. For instance, the American Foundrymen's Association recommends the following sizes of connections on grinders:

Size of grinding or abrasive cutting-off wheels	*Minimum inside diameter of hood outlet and branch pipe*
Up to 9″ diameter inclusive, not over 1½″ thick	3″
Over 9″ to 16″ diameter inclusive, not over 2″ thick	4″
Over 16″ to 19″ diameter inclusive, not over 3″ thick	4½″
Over 19″ to 24″ diameter inclusive, not over 4″ thick	5″
Over 24″ to 30″ diameter inclusive, not over 5″ thick	6″
Over 30″ to 36″ diameter inclusive, not over 6″ thick	7″

The size of the connection on uncoded hoods or enclosures is normally such as to provide a velocity of 3500 to 4000 feet per minute to the dust-laden air. Only when heavy concentrations of large heavy dust particles are found must the velocity be any higher.

The piping itself is ordinarily made of galvanized

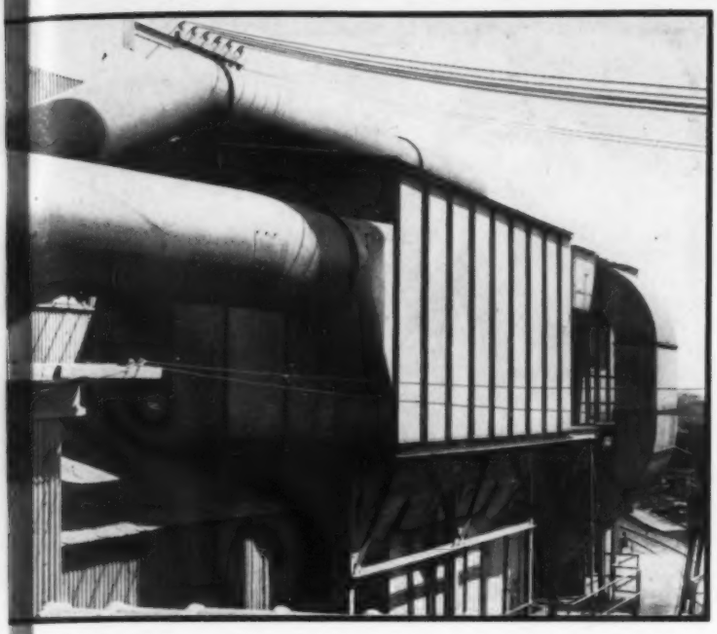


Figure 4 — Welded black pipe construction. Note cleanout openings.

metal of riveted and soldered construction, with the piping joints lapped in the direction of the air flow. The following gauges are often used although practical experience indicates that somewhat heavier piping is more economical in the long run:

	Gauge
3″ to 6″ diameter pipe	22
7″ to 12″ diameter pipe	20
13″ to 20″ diameter pipe	18
21″ and above diameter pipe	16

All elbows, Y's, and fittings should be two gauges heavier. Black welded piping with flanged, gasketed connections is often used but this construction is more costly. See Figure 3 for an example of galvanized pipe and various kinds of fittings. Figure 4 shows black welded pipe and one type of cleanout opening.

Branch connections should enter the main at the top or sides with the center-line angle being not over 45 degrees and preferably 30 degrees or less whenever possible, as shown in Figure 5. At the point where the connection pipe enters the other, a transformation piece is used with the area of the large end equal to the area of the small end plus the area of the connecting pipe. Only one pipe should enter another in the same transformation piece. Good design calls for these tapers to be sloped at top and sides only so that the bottom of the piping is one straight line, although this is not absolutely essential. As noted previously, it is good practice to make elbows and other fittings of heavier gauges than the straight pipe, as these pieces receive more wear. Ninety-degree elbows, 6 in. or less in diameter, should be made of five pieces; those above 6 in. in diameter should be made of seven pieces; the throat radius should be two pipe diameters where space permits. Air-tight clean-out openings should be spaced on 10 ft centers on all horizontal runs, particularly if the dust handled is moist or sticky. The piping should be supported by hangers spaced at approximately 12 ft. If the exhaust system is not laid out in a balanced resistance design, blast gates should be installed at each branch to control the flow of air.

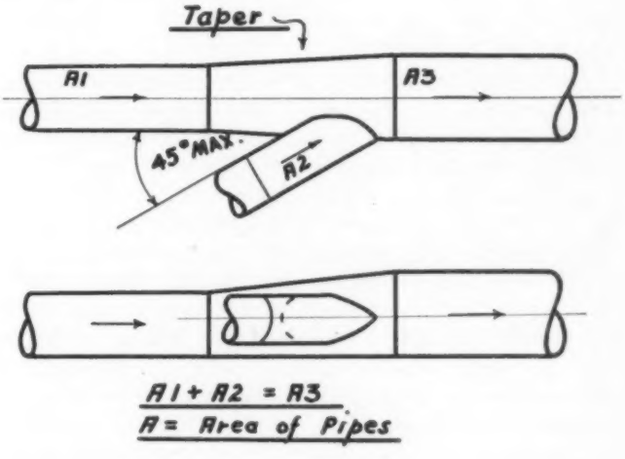
COLLECTION EQUIPMENT

Collection equipment or dust collectors should be installed in all dust removal systems and should be adapted not only to collect the kind of dust handled by the system, but also the collection efficiency should be such that the amount of dust passing beyond the collector does not create a nuisance or health hazard. There are three general types of collectors used in industrial exhaust systems: cyclones, cloth arrestors, and wet collectors.

The cyclone-type collector is the oldest design and is the type ordinarily seen around wood-working shops. This type of collector removes the dust by means of centrifugal force and gravity, by introducing the dust-laden air into a circular chamber so that the air passes downward on a helical path called the outer vortex which conforms to the outer shape of the cyclone chamber. The bottom section is cone-shaped, and the dust is removed by centrifugal action, with the cleaned air passing up through a center section known as the tubular guard. The efficiency of such collectors is not very high, running ordinarily 75 to 80 per cent by weight, and they are generally used where the air discharged is not obnoxious or when the dust is coarse and heavy. Due to the fact that they are all metal construction, they are particularly adaptable in handling hot gases.

The design of simple cyclones is extremely varied, although ordinarily the velocity of the air discharged through the center section should not be over 600 feet per minute. Cyclones can be operated either on a push-through or pull-through basis, and the discharge opening at the bottom should be closed off air-tight in order to obtain the maximum efficiency. The dust should be

Figure 5 — Sketch showing recommended practice in making branch connections.



continuously removed from the hopper, secondary hoppers often being built below the cyclone for this purpose. The inlet velocity into the cyclone should be at least 3500 feet per minute.

High efficiency cyclones having a collection efficiency of 95 per cent or greater are also widely used, these cyclones generally being of extremely small diameter in comparison to the standard type, thereby increasing the centrifugal action in the collector. It can readily be seen that in order to handle large volumes of air with this type of collector, they must be used in multiple with a common inlet and outlet. Multiple small high efficiency cyclones are adapted to wide varieties of dust. An installation of high efficiency cyclones handling hot gases is shown in Figure 6.

Cloth arrestors have been used for many years and may be either the screen, bag, or envelope type. They consist essentially of bags or screens mounted in a large sheet metal case with a hopper bottom. The case must be of flanged construction or reinforced in such a way to withstand the pressure involved in a dust collecting system. The cloth type of collector has an efficiency of 98 per cent or more, and is such that, if state laws permit, the air may be returned to the building. A cloth arrestor with one end extended to house the fan is shown in Figure 7.

Ordinarily the dust-laden air enters a settling chamber of the collector which may be at the side or at the bottom so that the heavier particles of dust fall out before the air is filtered by means of the cloth. The dust-laden air passes through the cloth at a low velocity and the cloth acts as a collecting medium. It must be pointed out, however, that the cloth ordinarily used does not do the collecting but the particles of dust adhering to the cloth and caught in the pores actually do the filtering and the cloth acts as a medium for holding this dust. The ordinary cloth arrestor must be shut down every four to eight hours, depending on the type and concentration of the dust, so that the screens or bags can be shaken to remove the collected dust, which falls down into the hoppers below. If the dust removal system is continuous in operation, cloth arrestors can be built in multiple units so that one section can be shut down for cleaning purposes while the other section or sections remain in operation. Such an arrangement is normally controlled by a timer, with automatic dampers either electrically or air operated which cut out one unit at a time so the dust may be shaken out of the cloth.

Ordinarily, the cloth used is a regular sateen which will handle most any type of dust at temperatures up to 175 F; if higher temperatures are encountered, the cloth may be of wool or asbestos. On one recent large installation, it was found that cloth arrestors satisfactorily collected dust 67 per cent of which was less than one micron in size and with all dust passing through a 325 mesh screen, with the air temperature running as high as 165 F. Some types of cloth collectors will handle air having a high percentage of moisture, although ordinary cloth arrestors are not recommended where the moisture is excessive. When this is the case, the collectors can be insulated so that no condensation occurs.

The size of a cloth arrestor depends primarily on the volume of air being handled, but the dust concentration and size of the dust particles must also be considered.

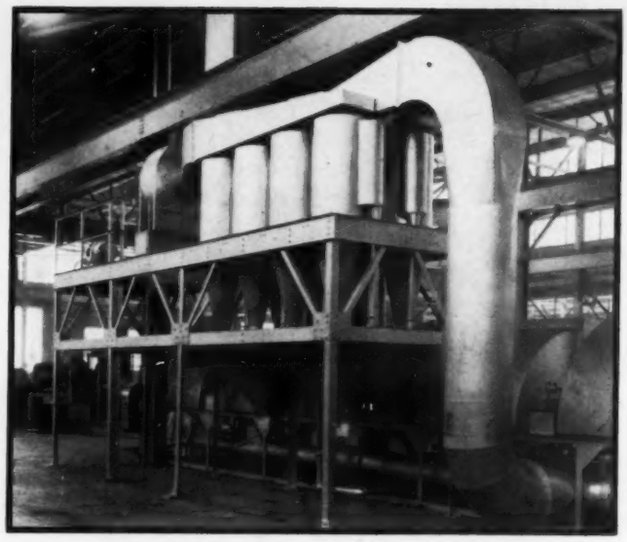
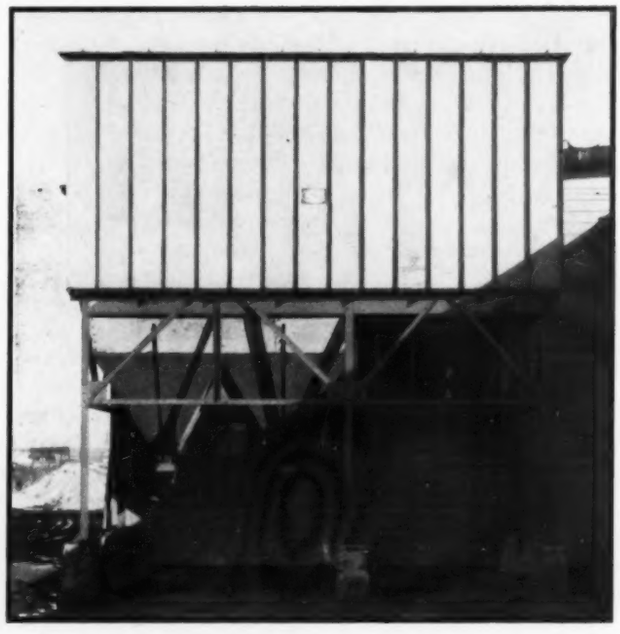


Figure 6 — Typical installation of multiple high efficiency cyclone collectors for handling hot gas.

▲

Figure 7 — Exterior view of cloth arrestor with one end of the housing extended to accommodate the fan.



The velocity through the cloth, or ratio of air to cloth, may be anything from one to four, depending on these factors. The greater the dust load, and the smaller the dust size, the lower the ratio required. Often settling chambers or ordinary cyclones are installed ahead of cloth arrestors to remove excessive dust loads and for classifying purposes. One of the advantages of cloth arrestors is that the collected dust may be returned to the system in the dry state, and often the value of the dust collected more than pays for the cost and operation of such equipment. On one particular job the dust collected, which had formerly been wasted to the atmosphere, was worth $100 per day.

Wet types of collectors are being used extensively and have a relatively high collection efficiency. They are particularly adaptable for handling hot dusty air,

or where there is a high percentage of moisture present. No trouble with freezing is encountered in the winter time if the exhausted air is at room temperature. The resistance through the wet collectors is constant if the moisture eliminators at the discharge end are kept in good condition.

The impingement type of wet collector is so constructed that the dirty air is forced to change direction by means of baffles and at each change of direction is impinged against a wet surface. In addition, the baffles are so arranged that the air stream breaks up the liquid into droplets which aid the collection. In the spray-type collector, the air passes through banks of sprays at low velocity and then may impinge, as before, on wetted baffles. The wet dynamic type collector uses a special type of fan which acts as a fan and dust collector. The dusty air passes through sprays located in the inlet of the impeller as well as in a cyclone-type precleaner. The action of the impeller is such as to throw the wetted dust particles and water through a by-pass into a sludge hopper.

It will be noted that the dust is collected in all wet collectors in the form of sludge, which may be wasted to the sewer or allowed to settle out in tanks so that the water may be recirculated. Dusts which are not readily wetted are not handled very successfully in the wet collectors although often a "wetting agent" is used in the water to help this condition.

FANS

The selection of the proper type of fan is important, as it is the fan which produces the air flow in the piping. In the majority of cases the fan is used to pull the dusty air through the collector, thereby saving wear on the fan as it handles only clean air. Ordinarily a centrifugal fan of the paddle wheel or planing mill exhauster type is used for either blow-in or pull-through systems, although the final selection depends on the volume of air handled, the friction loss through the system, temperature of the air and possibly space limitations. It is recommended that the fan be belt-driven by flat or V-belts. Such a drive allows for changes in the fan speed if it is found necessary to make such an adjustment. For handling high temperature gases, water-cooled sleeve bearings or ball bearings should be used, and fan manufacturers will make the proper recommendations for such cases.

GENERAL DESIGN

If possible, the arrangement of the equipment to be ventilated should be given a thorough study so as to provide a compact exhaust system. Unfortunately this can seldom be done, as the equipment must be arranged to suit the production flow and the exhaust system has to be designed to suit such an arrangement. It is much more economical from an operating standpoint to install a small individual system for an isolated dust point rather than run a long duct to it. Smaller dust collecting systems are preferable to large ones taking in a greater number of connections, as the smaller system is flexible from a maintenance standpoint and can be more easily altered when production varies. If it is anticipated that the system is to be enlarged in the future, such a change should be taken into account in the original design. Consideration must be given to the method of disposing of the collected dust, particularly if it is a waste product.

The calculation of the friction loss in the piping should include every factor entering into the system, and if other than standard air conditions are encountered, the variation should be taken into account. The normal method of figuring the friction loss of a system is to start at the point farthest from the fan, as this point generally causes the greatest resistance to air flow. Sometimes it is necessary to check a point nearer the fan for resistance, as such a point may have a smaller pipe connected to it so that the resistance is greater in this connection than the one farther away. In any event the first loss to take into consideration is the orifice loss, which depends on the shape of the pipe next to the hood. A plain straight connection has the most loss, a long tapered connection the next, and a bell-mouthed connection of two radii the least. Reference to handbooks shows these losses expressed in percentage of velocity pressure (VP) which is 1 in. of water at 4005 fpm velocity. To the orifice loss is added the velocity pressure in the controlling branch line.

The friction in the pipe is then figured, taking into account all elbows and bends. There are a number of charts and formulae available for estimating this loss, and they are not all in agreement, but the variation between them is not serious enough to throw the final calculation off very far on the ordinary system. At the point where a branch joins the main, there is also a loss; again handbooks give data for figuring this. Each different size of the main is figured in this manner and the calculation should be made in such a way as to act as a permanent record. The resistance of the collector is then added in, as well as the loss in the piping from the collector to the fan and from the fan to the atmosphere. A weather elbow or canopy top at the end of the fan discharge pipe is an additional item of resistance. The resistance across collectors can be obtained from the manufacturer and should be given from inlet to outlet of collector. In the case of cloth arrestors, the maximum resistance before cleaning of the cloth should be figured. Note that all losses are expressed in inches of water and the sun is the total pressure against which the fan is to operate.

MAINTENANCE AND INSPECTION

It must be recognized that practically all parts of a dust collecting system are subject to wear, particularly if the dust is abrasive. It is therefore highly desirable that periodic inspections of all parts of the system be made by the same person or department to make sure that nothing is worn out. As with any other piece of machinery, the worn or broken parts should be repaired or replaced immediately. Operators should be given strict instructions not to change or damage hoods or enclosures, or readjust blast gates. If wet or sticky dusts are being handled, the piping should be cleaned regularly so that the proper suction will always be maintained.

The collector itself should be given weekly inspec-

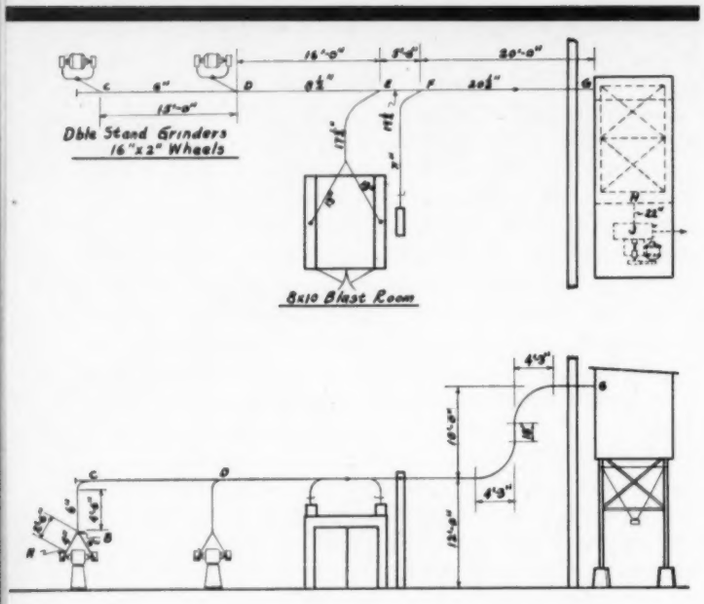


Figure 8 — General arrangement of a typical problem in dust collector application.

tions to make sure it is not worn in any way, and in the case of cloth arrestors, any wear in the cloth should be taken care of immediately to prevent further damage. The operating department should empty collector hoppers regularly, the frequency depending on the amount of dust collected. It is probably not necessary to mention that all bearings on collection equipment and fans must be kept lubricated, and that fan drives must be maintained at 100 per cent.

It is highly important that the plant engineering department make regular tests of the exhaust systems and that a thorough test be given the system immediately after its installation to make sure it is working in accordance with the original design. Records of such tests should be permanently kept, so that a particular system can be checked upon regularly and so that data can be obtained which will aid in the design of future systems.

A TYPICAL PROBLEM

Let us assume that the plant engineer is confronted with the problem of ventilating two grinder stands each having two 16 in. diameter wheels 2 in. thick, and

TABLE I

Calculation Sheet for Exhaust System

Location	Size	Area, sq ft	Cfm handled	Vel. fpm	Length	Add for elbows	Total eq. length	Loss per 100 ft	Loss total pressure	Remarks
Orifice	.....	.....	.....	4500	.....	.....	.....	.....	.82	
Inlet VP	.....	.....	.....	4500	.....	.....	.....	.....	1.26	
A — B	4″	.0872	392	4500	2′-6″	3′-4″	5′-10″	7.75	.46	
30° Y″ — B″	.....	.....	.....	.....	.....	.....	.....	.....	.....	Neglect because of regain due to decrease in velocity.
B — C	6″	.195	784	4020	4′-6″	5′-0″	9′-6″	3.85	.38	
30° Entry C	.....	.....	.....	.....	.....	.....	.....	.....	.17	
C — D	6″	.195	784	4020	15′-0″	.....	15′-0″	3.85	.58	
30° Entry D	.....	.....	.....	.....	.....	.....	.....	.....	.12	Takes into account regain due to decrease in velocity.
D — E	8½″	.394	1568	3980	16′-0″	.....	16′-0″	2.50	.40	
30° Entry E	.....	.....	.....	.....	.....	.....	.....	.....	.12	Takes into account regain due to decrease in velocity.
E — F	19½″	2.074	7968	3840	5′-0″	.....	5′-0″	0.90	.05	
30° Entry F	.....	.....	.....	.....	.....	.....	.....	.....	.19	
F — G	20½″	2.292	8968	3910	13′-0″	34′-2″	47′-2″	0.88	.41	
GH Collector	.....	.....	8968	.....	.....	.....	.....	.....	3.50	
H — J	22″	2.64	8968	3400	2′-0″	.....	.....	0.61	.01	
Total pressure on system	.....								8.47	Say 8½″

Size and make of collector			
Size and make of fan	Type	Rpm	Brake horsepower
Fan motor	Horsepower	Rpm	Frame No.
Drive			

an 8 ft x 10 ft x 8 ft sandblast room, arranged as shown in Figure 8. The grinders are already hooded and the dust to be handled is a health hazard.

By consulting the local state code, it is found that 4 in. connections must be used at each grinding wheel and that an average velocity of 4500 fpm must be maintained in these connections. The state code also specifies that the downdraft be not less than 80 fpm in the blast room. According to the manufacturer, the abrasive handling equipment used in conjunction with the blast room requires 1000 cfm for proper cleaning of the abrasive.

In order to find the amount of air to be handled from each grinder connection it is only necessary, of course, to multiply the area of the 4 in. pipe by 4500 fpm which gives 392 cfm each. The floor area of an 8 ft x 10 ft x 8 ft blast room is 80 square feet so that 6400 cfm must be exhausted from it to give an 80 fpm downdraft. The total amount of air to be handled is then:

From the grinders: $4 \times 392 =$	1568 cfm
From blast room proper	6400 cfm
From blast room abrasive cleaner	1000 cfm
Total	8968 cfm

A layout is then made to scale, showing the relative locations of the equipment involved from which the piping arrangement can be determined. From this it is found that there are no interferences with a straight run of piping as shown and that all the elbows may have a throat radius of two diameters. The piping sizes are figured as the layout progresses, based on a 3500 to 4000 fpm velocity in the mains and with branches entering the main at a 30 degree angle.

The final arrangement of the piping at the collector end depends on the type of collector used. In this particular case a collector of high efficiency is required because of the type of dust, so a cloth or wet type collector is selected. Ratings and sizes of either can be obtained from the manufacturer, and in the case of the cloth arrestor a ratio of 3½:1 is recommended; that is, the area of the cloth required is obtained by dividing the total volume of air handled (8968 cfm) by 3½. Furthermore, a classifier or settling chamber is desirable at the inlet end of a cloth arrestor to settle out the heavier particles of dust, thereby relieving the load on the cloth.

Let us assume that a cloth arrestor is finally picked and that it is decided to locate the fan in a fan house built as part of the collector. The air, according to state code, cannot be returned to the building because of the silica in the dust, so the fan will discharge to the atmosphere. The layout is completed and the friction loss in the piping then is figured, as shown in Table I, and should be kept as a permanent record. In selecting the fan to be used, note that the tabulation shows total pressure on the system, and that fans rated according to the National Association of Fan Manufacturers' code show capacities based on resistance or static pressure, which is the total pressure less the velocity pressure at the fan inlet. After the fan is selected the proper size of motor and belt drive may be picked.

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Crane Bridge Symposium

C. S. Shepherd
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ALLIANCE MACHINE COMPANY
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. . . . The four papers comprising this symposium were presented before the A. I. S. E. Pittsburgh District Section, January 10th, 1944 . . . . dealing primarily with crane bridge structures and drives, the papers bring out a number of good results emanating from use of the A. I. S. E. standard crane specifications . . . .

Lattice Girder Construction

By C. S. Shepherd

▲ THERE are in use at present many different types of construction for bridges of overhead traveling cranes. Some cranes are built for specific installations and are often highly specialized products in every respect. Many types, however, have been so extensively used that they may be considered as more or less standard construction. The crane bridge using two box girders is perhaps the most common. Another familiar type is that using two box girders with one or frequently two auxiliary lattice girders. The box girders in a similar type are sometimes replaced by single web plate girders, retaining the auxiliary girders in order to reduce torsional loads. It is the purpose of this paper to discuss crane bridges using single web lattice construction for both main and auxiliary girders, in comparison with some of the types previously mentioned.

There are several important factors which must be taken into account in selection of a type of construction for a proposed crane bridge. Assuming a choice of types which will give equal service in operation, initial cost is of course the feature in which the crane purchaser is primarily interested. The designer's main problem, particularly for cranes to be installed on existing runways, is frequently the space available. The maintenance superintendent is concerned about accessibility of parts for adjustments or replacements. For many installations the four-lattice-girder crane provides the answer to these requirements. In addition, it is particularly superior in efficiency of design, being lower in weight of crane per ton of lifted load.

On two-girder cranes, bridge drive machinery, footwalks and cab exert torsional loads on the girders. When magnetic control is used, control panels and resistors are frequently mounted on the footwalks. It is usually necessary, due to space limitations, to mount such electrical equipment outside the lineshaft. The additional torsional moment thereby imposed on the girders is an extremely important factor, affecting their design. The increased size of girder necessary to reduce torsional stresses may thus make the two-girder crane an uneconomical type for many installations.

The use of auxiliary lattice girders helps to decrease torsional loads on the main girders. However, unless torsion can be practically eliminated, box girder construction will still be indicated for the main girders. Furthermore, careful investigation will often disclose a lack of economy in the use of auxiliary girders in cases where box girders are used for the main girders. This lack of economy will occur when the weight of the auxiliary girder exceeds the additional weight which would be required to increase the box girder section sufficiently to provide resistance to torsional loads. This condition will obtain much more frequently than might commonly be supposed. On many cranes where

auxiliary girders are used, knee braces are added to decrease the L/b ratio of the top chord. These knee braces often interfere with location of stairs or ladders and of equipment on the footwalks.

The importance of proper design for resistance to torsional loads cannot be overemphasized. Some specifications consider torsional stress only as shear, disregarding length of span and distance between webs. These factors, however, affect not only the torsional stress in a girder, but, what is perhaps even more serious, the torsional deflection. Because the distance between trusses on a four-lattice-girder crane is much greater than the distance between webs on a box girder, the resultant structure is relatively stiff and strong in resistance to torsional loads. It is of course necessary to provide both top and bottom lateral bracing systems with cross frames at panel points. The bracing system, however, presents the same disadvantage as previously mentioned in connection with knee braces on auxiliary girders — a difficulty in locating equipment. It is desirable to install bridge drive machinery, control panels, resistors, etc., between the main and auxiliary girders. This can usually be accomplished, and a very compact crane design is the result. Careful planning of the entire crane bridge is, of course, necessary.

Early crane designs reflect lack of consideration for lateral stability of the bridge. A common form of construction for two-girder cranes was to have the girders resting on the end trucks and connected to them by four bolts. These bolts invariably became loose in service, allowing the crane to get "out of square." It is customary for operators on this type of crane to run up against the runway stops occasionally to "square" the bridge. Later designs recognized this lack of lateral stability, with its consequent racking effect on the crane bridge, by introducing bracing at the corners. End ties on modern cranes are in general designed with amply rigid corners. However, the lateral stresses and deflections in the girders themselves are frequently excessive.

One of the most important advantages of the type of construction under discussion is its lateral rigidity. As previously mentioned, four-lattice-girder cranes are commonly constructed with top and bottom lateral bracing between the main and auxiliary girders. These horizontal trusses, together with properly proportioned end ties, produce a structure offering considerable resistance to lateral loads. The end ties can be so designed that all four of the trusses are tied together at the ends, providing maximum lateral stiffness. Many specifications correctly require consideration of lateral loads amounting to 20 per cent of the weight of the crane plus lifted load multiplied by the ratio of driven wheels to total number of wheels. These loads are, of course, subject to reversal. It is therefore apparent that this feature is one that merits considerable investigation.

Another problem involved in the use of box girders is the distribution of trolley wheel loads into the webs of the girders. Since it is uneconomical to design the top cover plate of a box girder as a beam carrying trolley reactions into the webs, it is necessary to provide diaphragms at comparatively short spacing, bearing against the under side of the cover plate. Furthermore, for proper torsional resistance, diaphragms extending the full depth of the girder must be included. These diaphragms constitute a rather high percentage of the weight of the box girder and also add appreciably to its cost. When lattice girders are used, the web of the trolley rail is directly above the web of the top chord of the truss. It is necessary to design the top chord as a beam between panel points. This is usually accomplished without addition of much weight by using for the top chord a T-section or a pair of channels, back to back. Incidentally, either of these types of chord will provide a design exceptionally well adapted for welded construction.

One of the strongest arguments in favor of the use of lattice girders is the fact that their weight is considerably less than that of box girders having equivalent strength. In this connection, a comparison between modern steel mill cranes of the two types may be interesting. On a 10 ton, 112 ft, 0 in. span crane of box girder construction, the girders, which were 6 ft 8 in. deep, weighed a total of 62 tons. On a 10 ton, 116 ft 6 in. span crane of lattice girder construction, the total weight of girders and lateral bracing was only 39 tons. The girders for the latter crane were 11 ft deep. Another comparison of box girder versus lattice girder cranes may be made between two 10 ton cranes with spans of 71 ft 9 in. and 71 ft 6 in. respectively. The box girders weighed a total of 30 tons, while the lattice girders, complete with lateral bracing, weighed 26 tons. The box girders were 4 ft 4 in. deep and the lattice girders 7 ft deep. It is perhaps true that no great economy was obtained in this case by the use of lattice girders. However, at the time the crane was built, delivery of rolled angles and shapes was much better than for plates. This latter consideration naturally affected the decision in favor of lattice girder construction.

There are a number of other advantages of lattice girder construction for crane bridges. The lightness of the crane produces additional savings by permitting lighter runway construction. As a result of this economy, runways can, when necessary for clearance, be constructed high enough to provide for the greater depth of lattice girders as compared to box girder construction. Lighter wheel loads will mean greater life for axle bearings, wheels and rails, with no additional expenditure. Bridge drive motors can be made smaller with corresponding saving in cost of gearing and other parts of bridge drive mechanism.

For cranes on outdoor runways, wind loads are often a serious problem. It is obvious that the lattice girder, presenting less surface to the wind, holds an advantage over the box girder for such locations. The open construction is also an advantage from the standpoint of painting and inspection of the crane bridge.

There is another feature which we should not fail to consider at this time. The near future may bring to this country large numbers of orders for cranes to be used in the reconstruction of foreign industry. Lattice girders are particularly well suited for export since they can easily be shipped knocked down.

It is not the intention of this paper to suggest the substitution of lattice girders for box girders on all types and sizes of overhead traveling cranes. Their greatest economy, as indicated by actual comparisons of types, is found on cranes of relatively long spans and low capacities. However, detailed investigation of the type seems worth while and will often be justified by the decreased weight and cost.

THE USE OF

Lateral Stiffeners

By E. H. Windolph

▲ THE specifications of the A. I. S. E. on crane design as published in the August, 1942 issue of the *Iron and Steel Engineer* (p. 408, A. I. S. E. Yearbook, 1942) represents the first constructive attempt to place in the hands of all users and makers of cranes a set of specifications on crane design.

Under structural design, these specifications are broad in scope but nevertheless explicit as to the materials that can be used, the loads and forces and combinations to be used, the allowable unit stresses and also the detail of members and connections, and at the same time does not lose sight of the fact of the development of new ways of fabrication and the use of high tensile strength steels with all the freedom of practically no restrictions as to width-thickness ratio.

In considering the design and use of box girders, it is well to consider the conclusions as reached in the "Report of Crane Girder Tests" as published in the *Iron and Steel Engineer*, November, 1941, (p. 531, A. I. S. E. Yearbook, 1941). Some of the conclusions of importance are as follows:

1. Test results show that the whole girder section acts to resist lateral loads.
2. The stresses from vertical loads can be computed by the ordinary beam theory.
3. The torsional shear and the elastic twist of a girder can be computed approximately by R. Bredt's theory.
4. If latticed auxiliary girders are used in conjunction with the main girder, the whole structure acts as a space frame and secondary stresses are present.
5. The maximum lateral force is due to braking and the amount is equal to twenty per cent of the weight on the driven bridge track wheels; the speed of the bridge does not affect the lateral force, except in collision.
6. Impact due to bad rail joints can be of a considerable moment.
7. Jerk impact varies from 9 to 33 per cent.
8. The closer the load is to the hoisting drum, the greater will be the impact.
9. The slip which occurs in seams of built-up girder sections is appreciable under torsional loading and increases the twist and stresses.
10. Direct secondary stresses due to torsion are small in a box section.
11. Built-up welded box girders have a torsion constant close to that predicted by Bredt's theory.
12. The outstanding legs and parts of a box girder not included in the box have little effect on torsional properties of the section.
13. Longitudinal stiffeners are very effective in preventing buckling of the web when high h/t ratios are used.
14. Longitudinal stiffeners on thin cover plates of the compression flange will prevent buckling.
15. Vertical stiffeners are of little use in preventing compression web buckling.
16. With high unit stresses low h/t ratios should be used unless horizontal stiffeners are used.
17. The spacing of vertical stiffeners is the same for ordinary carbon steel or high tensile strength steel.
18. If the distance between webs is $^1/_{60}$ of the span for welded girders, or $^1/_{65}$ of the span for riveted girders no reduction of stress is necessary in the compression flange.

In the examination of the above, some of the items are a further confirmation of theories expounded and now proven by tests, and some are items that were brought out by tests. The use of the theory of elastic stability as applied to web plates and cover plates in compression, when horizontal stiffeners are used, allows more freedom for the use of thin plates and a further reduction of weight and cost, and this is especially so when you use a low alloy steel where h/t limiting values are more severe than in using ordinary carbon steel.

The use of stiffeners on thin plates placed in the line of stress have been used on square or rectangular shells, and this is also true of circular shells where approximations have been made, columns and other plate structures that act as compression members. The determination of the size of the stiffener and also the spacing does not involve a great deal of effort and has been fully covered by several authorities in treating elastic stability problems.

As an example, you can take a plate 10 in. x ¼ in. in the clear as in column construction or a compression flange as in a girder and it will actually take twice the load that a 20 in. x ¼ in. plate will take; if you would use a stiffener on the 20 in. x ¼ in. plate then the plate would take twice the load that the 10 in. x ¼ in. plate would take.

The same is equally true of plate girder webs; if you have a 5/16 in. web plate and place the vertical stiffeners 24 in. centers the shear value is 18,000 lb per sq in. but if you place the stiffeners 48 in. on centers the shear value is on 4500 lb per sq in.

The function of horizontal or vertical stiffeners is to prevent buckling of the web and thereby increase its stability. In other words a thin plate properly stiffened with ribs may be more economical to use than a thicker plate and this will be brought out later when we compare web plate thickness.

The use of horizontal stiffeners on the webs of girders is of only recent date and the method of procedure was brought out by Moisseiff and Leinhard and was published under the Proceedings of the American Society of Civil Engineers, January, 1940; the article was entitled "Theory of Elastic Stability Applied to Structural Design."

A study of the article is very interesting and shows the amount of effort necessary to develop workable formulae. The application of the formulae for determining the radius of gyration and also the required area of the horizontal stiffener is quite simple and the use of a chart that takes into consideration the ratios of web thickness to depth, the spacing of vertical stiffeners and required area of the stiffener is of material aid in designing.

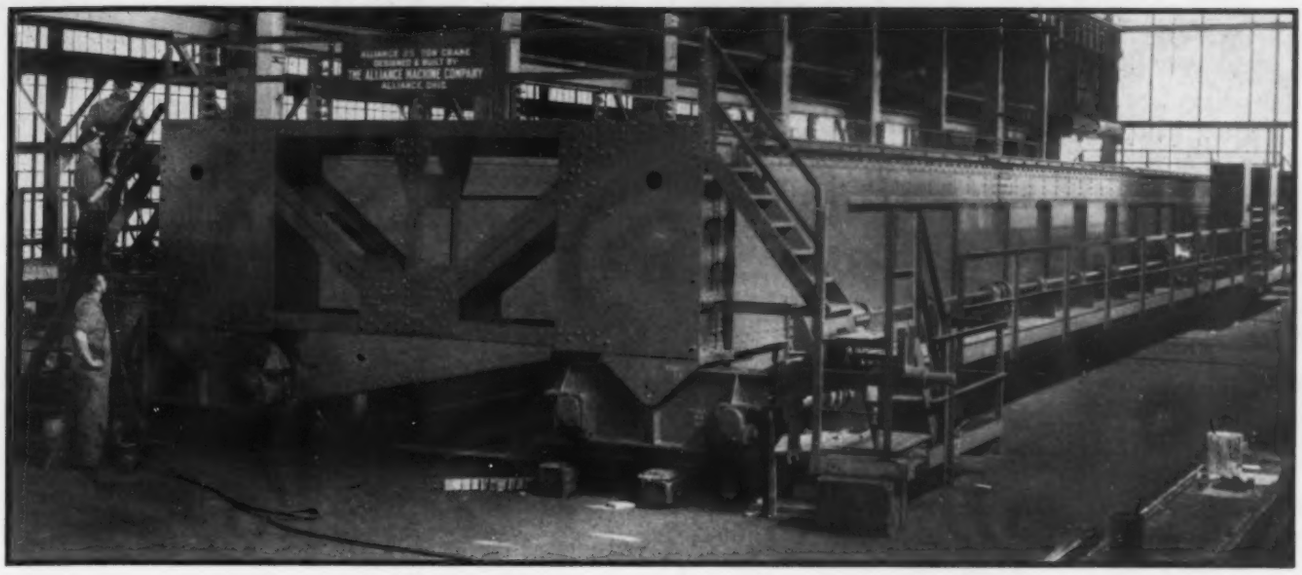


Figure 1 — Girders of riveted construction for 25 ton crane of 133 ft span.

The A. I. S. E. crane specifications have adopted the above procedure in design and profitable use can be had from them in the determination of web thicknesses. This is especially so when high unit stresses are used. At the present time, web plates ¼ in., 5/16 in. and ⅜ in. in thickness, stiffened horizontally, will take care of most cranes from 10-tons to 250-tons capacity if sufficient end depth obtains.

The thickness of web plates is controlled more by compression buckling than by vertical buckling in crane girders.

When using one line of horizontal stiffeners and 18,000 pounds per square inch for the flange stress and 4000 pounds for the vertical shear per square inch, the maximum depth of web plates is 76 in. for ¼ in. plates, 95 in. for 5/16 in. plates, and 114 in. for ⅜ in. plates. When using the same flange stress and the same vertical shear per square inch, but using two lines of stiffeners, the maximum depth of the web plates is 120 in. for ¼ in. plates, 150 in. for 5/16 in. plates, and 180 in. for ⅜ in. plates.

Using again your specifications for girders, when the flange stress is 18,000 pounds per square inch and without horizontal stiffeners the h/t ratio is 144 which gives a depth of 36 in. for ¼ in. plates, 45 in. for 5/16 in. plates, and 54 in. for ⅜ in. plates.

These comparative values of the three ways in the proportioning of the web plates of girders leads to the thought that horizontal stiffeners will be used on many long span and especially heavily loaded girders, and also where stiffness is required the increase in the moment of inertia of the section will not necessarily lead to lower unit stresses and waste of metal.

The design of the horizontal stiffener depends upon the radius of gyration required; and angles, zees, or bars can be used. The size of the stiffener depends upon the thickness of the web plate, and there is a ratio between the stiffness of the plate and the stiffness of the stiffener as there is also a ratio between the area of the plate and the area of the stiffener. As an example, we may assume that we have a 90 in. x 5/16 in. web plate with the vertical stiffeners on 90 in. centers, and the flange stress in the girder is 18,000 psi; if we use one stiffener the required radius of gyration is 1.70 or we could use a 3 in. x ⅜ in. bar welded to the web. If two horizontal bars were used the required radius of gyration is .97; or we could use two 3 in. x ¼ in. bars, and going a step further, we again assume that we have a 120 in. x ⅜ in. web plate with the vertical stiffeners 96 in. apart, and using two horizontal stiffeners the required radius of gyration of each stiffener is 1.13 and we could use 3 in. x 5/16 in. bars for each stiffener.

You can readily ascertain the possible savings in web material when horizontal stiffeners are used in place of low h/t values for the web. The accompanying illustrations show several girders designed using horizontal stiffeners. Figure 1 is a view of the girders for a 25-ton

Figure 2 — Welded girders for a 250 ton crane with a span of 90 ft 4 in.

capacity crane of 133 ft span and of riveted construction. The webs are 100 in. x 5/16 in. plates and we used one line of 4 in. x 3 in. x 5/16 in. angles for the horizontal stiffeners.

Figure 2 shows the girders for a 250-ton capacity crane of 90 ft 4 in. span and of welded construction. An extremely heavy trolley was used on this crane resulting in heavy shears. Carbon steel was used throughout and the cover plates are 50 in. x 1¼ in. plates, the web plates are 112 in. x 7/16 in., and two lines of 4 in. x ½ in. bars were used for the horizontal stiffeners and the girders weighed 48 tons each.

Figure 3 is a shop view of the complete bridge structure of a 300-ton hydraulic forging crane. In designing the girders for this crane a nickel-copper steel was used, with an allowable unit stress of 24,000 psi. This is probably the largest capacity crane with welded girders ever built, and also the first girders built using thin web plates and incorporating the use of horizontal stiffeners.

Figure 3 — Complete bridge structure of a 300 ton crane using nickel-copper steel in the girders.

▲

Figure 4 — View of one girder of the crane in Figure 3, showing horizontal stiffeners and vertical bars for footwalk and conductor supports.

Figure 4 is a view of one girder of this same crane, showing the horizontal stiffeners and also the vertical bars for footwalk and conductor supports.

Figure 5 gives a clear view of the side of the girder which faces toward the center of the crane and shows the horizontal stiffeners as to spacing and length.

The girders were designed in accordance with A. I. S. E. specifications, and a nickel-copper steel was used for the cover plates, web plates, and the horizontal stiffeners; carbon steel was used for the inside diaphragms and stiffeners and the outside shelf angle for the footwalk, together with the vertical bars for the footwalk and conductor supports.

The span of the crane, or the distance center to center of track wheels, is 100 ft, the total length is 103 ft 4 in., and the main material as used is as follows: 42 in. x 1¼ in. plates for the top and bottom flanges; 120 in. x ⅜ in. web plates; 5 in. x ½ in. bars for horizontal stiffeners; and 175 lb crane rails in two lines to support the trolley.

The weight of each girder, exclusive of the 175 lb rails, is 47 tons.

The use of 5 in. x ½ in. bars for horizontal stiffeners was occasioned because that size bar was available although a 3 in. x ½ in. bar was ample for the required stiffness.

In the construction of the girders the welds made (length and size) for two girders are as follows:

531 ft of ¼ in. continuous fillet welds
555 ft of 5/16 in. continuous fillet welds
1432 ft of ⅜ in. continuous fillet welds
4 ft of 1 in. continuous fillet welds
10 ft of ¼ in. continuous vee welds
283 ft of ⅜ in. continuous vee welds
40 ft of ½ in. continuous vee welds
28 ft of 1¼ in. continuous vee welds
1447 ft of ¼ in. fillet weld (laid) for the intermittent welding.
Total — 4330 ft.

The web plates were placed 2 ft 6 in. apart and full length plates for diaphragms were placed at each footwalk, motor and gear box support; short plate diaphragms on approximate 2 ft centers were used to support the rail between the full length diaphragm plates, and where necessary a 6 in. x 4 in. x ⅜ in. vertical stiffener angle was welded to each web plate with the toe of the 6 in. leg welded to the web plate. The top horizontal stiffener bar was placed a distance of 15½ in. from the top of the top flange plate to the center of the bar and the two bars are on 19½ in. centers. The maximum spacing of diaphragms near the center is 7 ft 6 in.

The end shear on each web plate is 305,000 pounds and is the sum of 35,000 lb from dead load, 208,000 lb from live load, 29,000 lb from impact, and 33,000 lb from torsional shear. The total shear at the center is 129,000 pounds on each web plate.

If these girders were designed under the old conventional method, using the same depth of 120 in. and following the A. I. S. E. specifications of an h/t value of 121, the webs would be 1 in. thick. If an h/t value of 135, which is in line with other specifications when a

Figure 5 — View of side of girder of the crane in Figure 3, showing spacing and length of horizontal stiffeners.

smaller factor of safety for the web is used than for the flanges, the web would be 7/8 in. thick.

The savings in weight for the web plates for two girders, due to the difference in web thickness is 105,400 lb if 1 in. plates were used, and 84,320 lb if 7/8 in. plates were used. If the conventional method of design is used and for any safety factor for the webs which does not approach unity, you become immediately aware that web plates of a high tensile strength steel present numerous difficulties in design when you attempt to establish the web thickness at the center of the girder where the horizontal stress is maximum.

It does not take very much imagination if you want to reduce weight, to see that thin webs with horizontal stiffeners have many advantages and it is further proof that the theory of elastic stability is the development and use of the fundamental laws that govern the behavior of metal in compression.

When we consider some of the old plate girder bridges that were constructed of carbon steel, where a low unit stress was used, we may find that the center web section was 3/8 in. thick and the thickness was graduated until the end section was 5/8 in. thick. This change in web thickness, you might say, is due to the increased vertical shear and since the horizontal shear or stress was low the practice was allowable and is still allowable but seldom practiced for economic reasons. With a high tensile strength steel and the old method of design we would be justified in reversing the above thickness and use a 3/8 in. web plate at the ends of the girder and gradually increase the web thickness toward the center where the thickness might be 5/8 in. or more.

In box girders for cranes the vertical web shear is not great when the flanges are parallel and this is also true for the web shear at the center of girders with the sloping lower flange, or fish-belly type. The horizontal shear at the center, of course, is maximum and with unit stresses which are high and especially so with high tensile strength steels, the h/t ratio makes it mandatory to increase the web thickness unless horizontal stiffeners are used. The h/t ratio for carbon steel in accordance with various specifications ranges from about 140 to 200 and with high tensile strength steel, from about 105 to 150. The ratios depend upon the stress and what safety factor is used and probably sometime upon the designer's conscience.

The use of vertical stiffeners, unless placed so as to decrease the half wave length in the web plate, will not increase the strength of the plate against buckling, and the cost would not compensate for the use of thin plates in ordinary construction where the web plate is to carry the shear to the points of support.

If thin web plates are used, with vertical stiffeners that will take part of the cumulative shear, and where waves are produced in the web plate, we have two systems to transmit the shear to the end supports. One system is by shear in the web and the other system where the webs act as a diagonal in a truss and the stiffeners as an intermediate post in a truss. This method of design does not seem satisfactory for ordinary construction and more tests of actual girders seem necessary before this method can be written into usable specifications. If a moving load is used upon the top of the girder, the matter would become more complex.

Some studies have been made of the use of high tensile steel for flanges and carbon steel for webs on account of the high h/t value and also the cost differential. This seems merely to indicate that two different safety factors are used but does not take into consideration the different behavior of the two metals.

If I-section girders were made up by using half sections of wide flange beams with high tensile properties and the web between the two flange sections of ordinary carbon steel, it would be possible to make girders about 108 in. deep provided welding difficulties do not arise.

At the present time, for ordinary construction it seems that we only have two methods for designing plate girders, one with the use of webs stiffened by vertical stiffeners and the other method with the use of thin webs with horizontal and vertical stiffeners.

Many chapters have been written on the design of web thicknesses and the size and spacing of vertical stiffeners based upon the various unit stresses used and safety factor used. Many girders today are designed with one factor of safety for the flanges and another safety factor for the webs when the material is the same; this procedure seems warranted for certain kinds of construction as a slight buckling of the web only means that the stress in the flange has been increased when the web fails to take its full longitudinal shear or compressive stress.

In crane girder design it seems more reasonable to use one safety factor for both the web and flanges on account of the almost continuously overloading conditions.

Sometimes the same specifications call for an h/t ratio of 160 for single web girders and an h/t ratio of 200 for double web or box girders. The difference in the ratios does not seem warranted.

With the coming of tomorrow, when it will again be possible to use a steel with a high yield point, it becomes increasingly clear that h/t values for web plates will become extremely severe if allowable unit stresses approach 30,000 psi or even above, and this is also true for w/t values for cover plates in box girders.

The use of higher yield points will undoubtedly bring about the use of horizontal stiffeners for the webs in girders, cover plates of box girders, columns, and plate structures.

We can even today effect a saving of no small amount through the use of horizontal stiffeners in large box girders when you consider the savings in material used, lesser charges in freight (especially on long hauls), less weight handled in the shop and field, and the possible use of present shop and field equipment without the use of auxiliary equipment.

For many years we have heard the old story that in Europe the price of material was high and that labor was very cheap, and due to these conditions their structures for the same carrying capacity were lighter in weight than what we built in this country. I cannot agree with that statement in full. There may be some truth in the matter but I believe you will also find that more care was used in ascertaining the possible loads and forces acting upon the structure, and the use of the structure; and also more care was used in the matter of details with the result that better engineering was exercised at times.

When we really start to use low alloy steels with the additional cost over carbon steel, we will probably also start to cut corners and give more attention to the design of main members and also detail connections. It would not be out of place to be more exacting in the use of carbon steel and I believe the trend is in that direction.

For comparison, a fair example would be a box girder constructed of carbon steel with 48 in. x 1¼ in. cover plates, two web plates 120 in. x ⅜ in. and two lines of 3 in. x ½ in. stiffeners on each side of the web for a girder 100 ft long. In this instance we have a flange area composed of 60 square inches from the flange plate and using 1/6 of the web as in welded girders, we have an additional area of 15 square inches, or a total of 75 square inches for flange area. The total area of this girder per foot of length is the sum of the two flange plates, two web plates, and four lines of stiffeners or a total of 216 cubic inches per inch of length.

In comparison with the above we can use the old conventional method of designing girders without the use of horizontal stiffeners and use an h/t value of 160, which is rather high on a girder that must take both vertical load and horizontal forces, with an allowable unit stress of 18,000 pounds. We first find that the webs would be ¾ in. thick, which in turn would allow 30 square inches for flange area. As 75 square inches is the required flange area, the flange plates we can use would be 48 in. x 15/16 in. plates. This would give a total of 270 cubic inches of metal per inch of length.

From the above figures we arrive at a difference in weight of 18,360 pounds for each girder, or 25 per cent, in favor of the girders with horizontal stiffeners, and to offset this saving we have the cost of welding on the horizontal stiffener bars.

When it again becomes possible to use low alloy steels with high yield points, the savings would be more as the h/t values may become as low as 110. In box girders when we consider h/t values as low as 110, we must of course consider a new approach in design, and this may or may not reduce the total cost if we think of girders of latticed construction, or a single web girder with an auxiliary latticed girder with both girders laced together; or we can use horizontal stiffeners and thin webs with the reduced savings in cost.

The electric steel annual capacity today is somewhere between 6 and 7 million tons, and when the war is ended the mills will look for further outlets for their product. We will probably have alloy steels with extremely high yield points and means will undoubtedly be found for the use of this product.

The use of alloy steels that are corrosion resistant should also have more consideration in crane construction and should be studied. Hot metal cranes, soaking pit cranes, slag yard cranes, cranes in fertilizer plants, etc., could well be viewed with this in mind.

In closing, I ask that everyone give further consideration to the A. I. S. E. crane specifications and incorporate them in their own crane inquiry and specifications. A study of the average specification on crane girder design heretofore has been sadly lacking in the necessary requirements for intelligent designing. No crane specifications have ever been written that can approach the A. I. S. E. specifications for clearness and breadth of scope.

SOME ITEMS AFFECTING *The Cost of Cranes*

By W. C. Heinle

▲ THE feeling seems to be general that too great an investment is put into overhead traveling cranes for steel mill service, and that a determined effort should be made to reduce this cost. This problem was put before the Crane Committee of the Association of Iron and Steel Engineers. After considerable discussion, the committee held that unnecessary weight was used in some parts of the crane, and that a reduction in this direction would decrease the cost; the bridge girders seemed the logical starting point, and a program was set up with several research engineers of Lehigh University to investigate the different factors entering into crane girder design. ("Report of Crane Girder Tests," p. 531, A. I. S. E. Yearbook, 1941. "Specifications for Electric Overhead Traveling Cranes," p. 408, A. I. S. E. Yearbook, 1942.)

From this investigation a formula was derived which indicated that in many cases girders could have been much lighter in weight without impairing the serviceability of the crane. Recently there have been cases where substantial savings have been made, particularly on heavy capacity, long span cranes. There have also been added, however, in recent years, other specifications which add to the cost.

TROLLEY

The trolley construction originally had all motor pinions mounted on the armature shaft, with the electric brake on the opposite end of the motor. This permits the simplest arrangement of machinery and gives very satisfactory results, as the trolley frames are now one piece construction with the motors keyed in place.

It is now usually required to have the motors coupled,

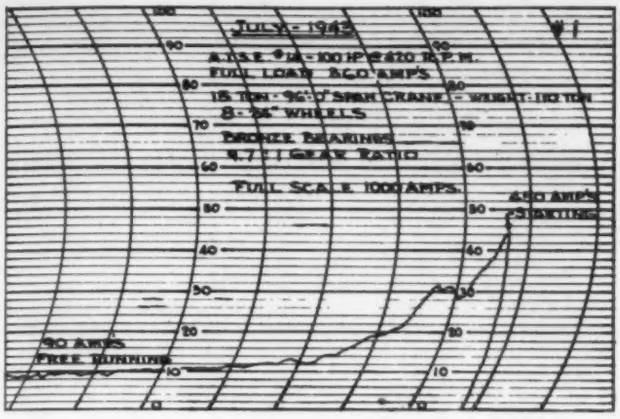


Figure 1

particularly on the hoist motion, with the brake mounted on the outboard end of the motor shaft extension; this requires an additional shaft for the pinion, with bearings and their supports, and an outboard support for the brake and a flexible coupling between the motor and pinion shaft. This arrangement on the hoist only with a 65 or 100 hp motor adds $500 to $600 to the cost.

Present specifications usually require an additional brake. On 15 ton capacity hoists and larger, this second brake mounted either on the motor armature or on the motor gear shaft, using a duplicate brake on a 65 hp motor, amounts to approximately $600, and on a 100 hp motor, $800.

The present design of brakes and mechanical equipment makes failure due to breakage a very remote possibility, and it would seem this additional brake could be omitted, unless some hazard, such as handling hot metal, requires it as a safety measure.

On heavier capacities it has seemed advisable to arrange the upper block sheaves so they can be removed through the top of the trolley, rather than from below. This usually results in less compactness, and adds more weight.

Large knee braces in the building quite often cause difficulty in providing a good design, one which will produce the required hook clearances.

BRIDGE DRIVE

The simplest construction for this unit, which we will call No. 1, and the one which has been most universally used, consists of the bridge track wheel and drive gear mounted on an axle between two bearings, the drive pinion on a shaft between two bearings on the end truck, a countershaft motor at the center of span, the motor pinion on the armature shaft, the gear on the countershaft, and these shafts connected by several sections of lineshaft through rigid couplings.

A half flexible coupling has been added at either end of the crane to connect the short pinion shaft to the through shafts. This should not be necessary on four wheel cranes if a proper connection is made between the girders and end trucks.

A second arrangement, instead of using the countershaft motor, has the motor mounted above the line shaft and connected to a short shaft on which the pinion is mounted through a flexible coupling. This permits the use of a narrower walk at this point, but does add a number of moving parts.

In this second case the cost will be about equal to No. 1, if it is compared to the price of anti-friction bearing countershafts, but will be several hundred dollars more than No. 1 with sleeve bearing countershafts.

A third arrangement consists of a double reduction gear box located at each end of the crane, preferably mounted on the footwalk; one side of each gear box is connected to an extension of the track wheel axle through a short intermediate shaft by half flexible couplings; the other side is connected by rigid couplings to a through line shaft which is connected directly to the motor armature shaft by half flexible couplings. While this also permits locating the motor close to the girder, it does add a great many wearing parts.

Using a 15 ton 80 ft span crane, with a 65 hp motor, as an example, the cost of the drive, including the track wheel units, will be approximately $3500 for arrangement No. 1, and $5100 for No. 3.

With this third arrangement there has been a tendency to reduce the size of the line shaft under that used in No. 1 or No. 2. This, however, has given considerable trouble in some cases, due to a whipping action caused by the speed of the motor which attains a speed of 600 to 1000 rpm.

There is also a tendency to require a double bridge drive on eight wheel cranes — that is, a drive on each girder. This at least doubles the cost of the single drive. The load will not usually divide equally between the motors.

Unless there are special conditions to be met, two driven wheels on an eight wheel crane will give satisfactory operation, as shown by many cranes now in service with the single drive.

Since the use of anti-friction bearings for bridge track wheel axles, there has been quite a difference of opinion as to the proper size of bridge motor to use. It has been shown by actual test that most cranes of this type have been considerably over-motored, resulting in a speed of 150 to 175 per cent of that specified.

The accompanying chart was taken recently on a crane equipped with bronze instead of anti-friction bearings. This is a 15 ton 96 ft span crane, weighing 220,000 pounds. The formula suggested by the A. I. S. E. Crane Committee, using 7 per cent friction coefficient with 90 per cent overall efficiency, figured 42 lb per ton draw bar pull. The speed was supposed to be 400 fpm, which figured 56 hp. The motor used is an A. I. S. E. standard No. 14, 100 hp at 420 rpm, full load current 360 amp. The gearing was calculated from the speed of the motor at 56 hp.

Note from the chart the maximum current to start the crane is 450 amp, which is only 125 per cent full load current. When the maximum speed is attained only 90 amp are used. This corresponds to approximately 24 hp at 900 rpm, giving a bridge travel of 600 fpm, and making the draw bar pull 13 lb per ton.

The crane has eight 24 in. wheels, with a single motor driving two wheels through a gear ratio of 9.7:1. The bearing surfaces of the track wheel axles are hardened, and ground to a very smooth finish; the oil boxes are dust-tight.

This low power consumption, no doubt, is also due to

the use of taper wheels, with plenty of side clearance between the wheel flanges and runway rail, eliminating side friction.

Other charts taken on a number of cranes also seem to indicate that with the proper lubrication, the power to operate the bridge is considerably less than that indicated by the formula.

These results indicate that in a great many cases a smaller motor could be used if the service is properly analyzed, which would make a saving of $600 to $1000 for the electrical equipment alone.

WALKS AND STAIRWAYS

It has seemed desirable for safety and convenience to have numerous stairways, landing and repair platforms, so that easy access may be had to all parts of the crane. These do not add greatly to the weight, but the cost will range from several hundred dollars to $500 for each unit added.

Locating all control equipment on the walk results in a width of six feet or more for this member, and quite often the addition of an outrider girder to aid in supporting this equipment in a rigid manner.

The use of expanded metal instead of ¼ in. checkered plate for the floor would reduce this weight from 11½ lb to 4½ lb per sq ft.

ELECTRICAL EQUIPMENT

There are wide variations in electrical specifications and methods of installation; the addition of lights for illumination, signal lights, heaters, ventilators and safety switches for the various pieces of equipment has quite a bearing on the cost.

For service where the maximum load is infrequently handled, with rather intermittent operation, the factor of safety could be reduced, as high speeds are not usually required.

The foregoing remarks are intended to only indicate some of the requirements which have tended to increase the cost of cranes; they are not offered as a recommendation for the alteration of any steel mill specifications, as these can only be determined by the purchaser, who knows best the conditions to be met for each particular installation.

Starting Currents AND *Distribution* OF LOADS IN BRIDGE DRIVE MOTORS

By E. J. Posselt

▲ THIS discussion will be limited to control for d-c series motors as this is the type generally used on mill cranes. Reference will be made to magnetic control rather than manual control, on the assumption that for safety and operating reasons this is preferred on the cranes being considered. The results, of course, are the same for either type of control if conditions are duplicated. Factors affecting starting currents for single motor drives and load distribution for two motor drives on bridge motions will be investigated.

Maximum starting currents are determined by the horsepower rating of the motor, the total resistance of the starting resistor, the number of accelerating steps and the resistor taper selected for these steps, and finally, the rate of acceleration.

The crane builder selects the motor size on the basis of the crane application and the crane design to meet the specifications of the order. A slow speed bridge may require a different size motor than a high speed bridge of the same weight capacity.

After the motor has been selected, the control manufacturer will recommend the control and resistor on the basis of the motor horsepower rating according to N. E. M. A. standards. For a roller bearing crane with reversing plugging service, the controller will be provided with one plugging and three accelerating contactors. The resistor will allow a starting inrush of 50 per cent of full load current on the first point of the master switch, in accordance with resistor classification 152 or 162. This inrush corresponds to approximately 38 per cent full load torque.

The resistor taper or stepping is usually selected on the assumption that all accelerating peaks should be approximately equal or successively increased, if the accelerating contactors are timed to close in sequence when the current has decreased to about 100 per cent.

Figure 1 shows a set of typical characteristic curves which indicate the relation between rated speed and rated torque or current for each of the five speed points of the master switch. The solid line indicates torque and the dotted line current. It will be noted for each speed point, the solid and dotted line curves cross at 100 per cent load.

Only 50 per cent current is obtained on the first point when starting because sufficient total resistance must be provided on this point to limit the motor current to a safe value when plugging. The value of resistance required for a 162 resistor classification, will result in approximately 155 per cent current if the motor is running at 215 per cent rated speed when it is plugged. Actually this current will be lower because the curves in Figure 1 do not take into account the effect of inductance, loading of the motor, etc., all of which tend to round off the inrush peaks.

The value of resistance in the plugging step and each of the accelerating steps is proportioned to provide suitable accelerating curves. The magnitude of the inrush obtained as each accelerating contactor closes depends upon the motor speed and the value of resistance remaining in series with the motor. Figure 1 indicates that, if the motor is plugged and the plugging contactor P is set to close when the speed has decreased to about 15 per cent, an inrush of about 113 per cent current, corresponding to about 118 per cent torque, will be obtained. Since it is common practice to use a motor counter voltage method for controlling the plugging contactor, the same inrush will always be obtained when the plugging contactor closes, for any plugging speed above 15 per cent rated speed. Although loading conditions may vary over a wide range and cause differ-

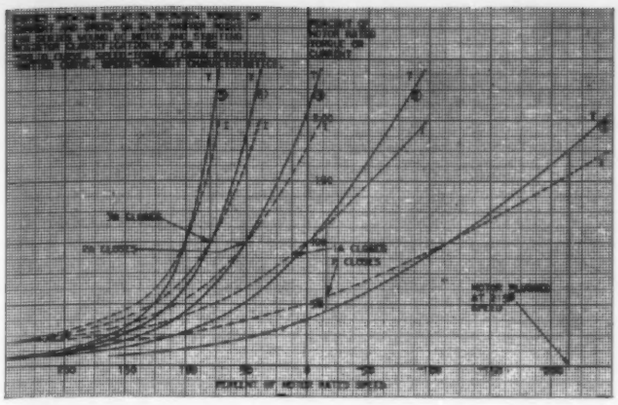


Figure 1

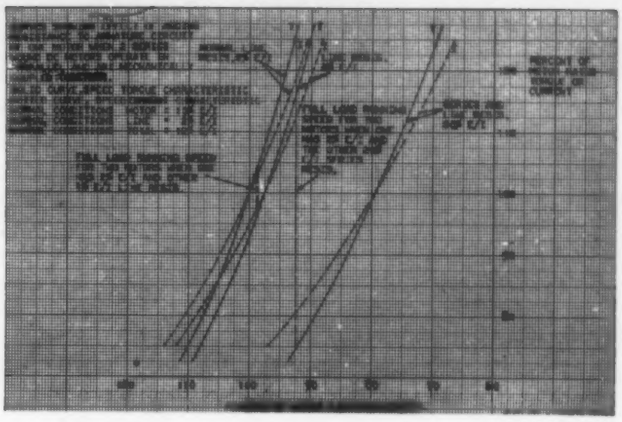
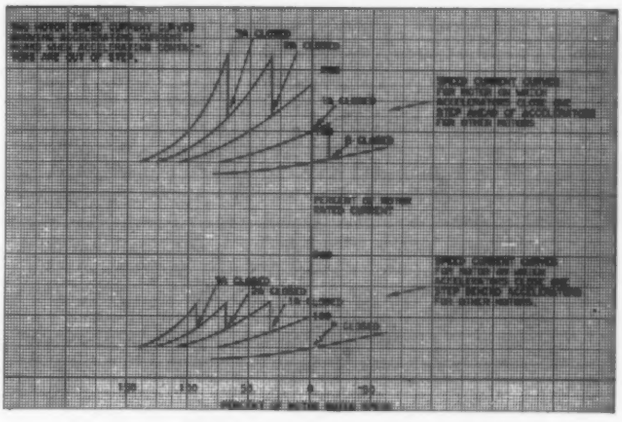


Figure 2 ↑

Figure 3 ↓



ent rates of deceleration when plugging, this inrush will not be changed.

It is customary to control the accelerating contactors by a definite or modified timing method. Figure 1 shows an approximate current inrush of 155 per cent when 1A closes and 165 per cent when 2A and 3A close. These inrush peaks will be different if the accelerators close at some other motor speed. As the motor acceleration rate will change when loading conditions change, the accelerating peaks will be different because the accelerating contactors will close at different motor speeds.

It is usually easier to change the accelerating peaks to suit operating requirements by adjusting the individual contactor timing than by changing the resistor taps. Whenever contactor adjustments are made, they should all be checked to insure a correct relationship between successive accelerating peaks.

On the assumption that all the accelerators are timed to close in sequence when the current decreases to the same value, the following relationships apply:

1. For a fixed number of steps, the accelerating peaks are minimum when they are all equal.
2. If the total value of resistance and the number of accelerators are specified, this would determine the possible minimum accelerating peaks.
3. If minimum accelerating peaks are desired with a given number of accelerators, these factors would determine the total value of resistance required. Any value of resistance above or below that total would result in a higher accelerating peak.
4. If the total amount of resistance and the accelerating peaks are specified, this would determine the number of accelerators required.

When it is desired to increase the rate of acceleration it will be necessary to increase the accelerating peaks by decreasing the timing of the accelerating contactors. As can be seen from the curves, for values above 100 per cent load, the per cent torque increase is greater than the per cent current increase. The curves indicate that when the current is 200 per cent the torque will be 241 per cent of motor rated values. Current measurements alone do not indicate torque produced. Slipping of the wheels may occur if excessive torque peaks are allowed.

On duplex motor drives using two motors operating in parallel, the foregoing discussion applies to each of the motors. In addition it is important that the loading be distributed so one of the motors will not be overloaded. Both electrical circuits should be balanced to insure equal division of the load between the two motors.

When operating on the last point of the master switch, the motors are connected across the line so the controller will have no effect on the load division. The load will be equally divided if the mechanically connected load is equal for both motors, if the motor characteristics are alike, and if the cables connecting the two motors to the control panel have equal resistances. Crane motor characteristics probably do not vary enough between different motors of the same type to make any appreciable difference in load division. In the calculations for plotting the curves of Figure 1 an average resistance value of 2 per cent E/I for the cables has been included. E in this factor is the line voltage and I is rated full load current of the motor; 10 per cent E/I has been allowed for the motor armature and series field resistance. If an extreme condition is considered in which the cables for one motor are twice as long as the cables in the other motor circuit, then the total resistance in one motor circuit would be 14 per cent E/I and the other motor circuit 12 per cent E/I. Under this condition with full load, both motors would run at approximately 98.8 per cent rated speed. The motor with the short cable would take about 103 per cent current and the motor with the long cable would operate at about 97 per cent current. This is shown by the curves in Figure 2.

On the assumption that the cable resistance is normal for both motors but the last accelerating contactor for one of the motors failed to close, then one of the motors

would operate with a line resistance value of 2 per cent E/I and the other motor with a total line resistance value of 20 per cent E/I. With full load, both motors would run at about 92.5 per cent rated speed as shown in Figure 2. One motor would operate with about 119 per cent current and the other with about 74.5 per cent current. Under these conditions one motor provides approximately 125 per cent torque and the other motor about 75 per cent torque. Although this condition is not desirable the equipment could be operated during an emergency until corrections are made. If one of the other accelerators had failed to close instead of the last one, the unbalancing would be greater and probably result in a noticeable difference in the operation of the bridge.

It is now recommended practice to build these duplex controllers with separate accelerating resistors for each motor. It is necessary to close the corresponding accelerating contactors together to insure equal load division during acceleration. Curves shown in Figure 3 indicate the accelerating curves for each of the two motors if the accelerating contactors are one contactor out of step. This shows the maximum peak current for the motor on which the accelerators close first is about 220 per cent and the other motor only about 120 per cent. This peak current is about 33 per cent above the normal maximum peak of about 165 per cent when the corresponding accelerating contactors close together.

Unequal division of load between the two motors during acceleration, similar to the foregoing, will be produced if the corresponding steps of the accelerating resistors are not equal. Unless there is something radically wrong with the resistor connections, slight variations in corresponding resistor values will not result in as much load unbalancing as when the accelerating contactors are out of step.

If the electrical equipment for duplex drives is built so that corresponding accelerators for the two motors will operate together, and if reasonable precautions are taken so the resistance in each motor circuit is the same, the accelerating peaks and running currents for one motor should be practically the same as for the other motor.

With electrical circuits that are normal and equalized in values, unequal motor currents would be obtained if the motors run at different speeds due to mechanical differences. The motors on a two-motor drive may be coupled together directly or, in the case of a double bridge drive, the coupling is through the driving wheels and track. With direct coupled drives, the two motors must run at the same speed so the motor currents will be equalized. On a double bridge drive, the motor speeds may not be exactly the same. If one set of wheels are not the same diameter as the other set because of unequal wear, or if one set of drivers slip, the motor currents will not be equal. At full load, if one motor runs 10 per cent slower than the other motor, it will run with about 115 per cent rated current and this will be about 35 per cent higher than the current for the faster motor.

On some two-motor drives the motors are connected permanently in series instead of in parallel. In this arrangement standard full voltage motors may be used with a single motor type of controller. With this scheme the starting, accelerating and running currents will be the same for both motors. Each motor will operate on half voltage so the speed at rated torque will be slightly less than 50 per cent rated speed. This method may simplify the gearing on applications requiring rapid acceleration and reduced top speeds. The two motors used in this arrangement would probably have a higher horsepower rating than the motors which would be used for a parallel motor scheme, but the controller cost, size and weight would be less than a duplex controller.

A definite advantage of a two-motor drive over a single motor drive is that, in an emergency, the crane may be operated with one of the motors while the other is temporarily out of service. A duplex controller requires a larger panel and is heavier than a single motor controller for the same horsepower.

There are many details to be considered when making a selection of the type of drive for a crane bridge. The foregoing discussion indicates that the scheme using two motors connected permanently in series or a single motor drive is preferable if minimum maintenance, minimum adjustment and simplicity of control equipment are of prime importance.

DISCUSSION

PRESENTED BY

JAMES FARRINGTON, Superintendent, Electrical Department, Wheeling Steel Corporation, Steubenville, Ohio

J. A. JACKSON, Machinery Manufacturers Section, Industrial Engineering Division, General Electric Company, Schenectady, New York

E. H. WINDOLPH, The Alliance Machine Company, Alliance, Ohio

F. E. KLING, Assistant Chief Engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

C. S. SHEPHERD, American Bridge Company, Ambridge, Pennsylvania

James Farrington: We feel that the research work of our crane committee in regard to the development of crane girders has amply repaid the Association for the money expended in this work. I think it will result in quite a saving, not only in the weight of crane but also in the time required to build it, and will reflect all the way down along the line in the design of the building.

When we ask for a crane of 50 tons capacity, do we really need a 50-ton crane or should it be made to take 100 tons or 125 tons? The builders say: "If you will guarantee it will not have to take over 50 tons, we can materially reduce the price." But we do not seem to be able to sell that idea to the operating man. Have crane builders ever thought of applying a device to limit overloads? Instead of overloading a crane of 50 tons where the load is 100 tons, is there any device we could put under the girders and then remove it, even though it may take several hours to put it on? We now have two cranes where the camber has been stretched out and the trolley runs to the center of the bridge, due to overloads.

I would like to ask the crane builders if the cost of the lattice type girder is the same or less than the box type, and will the lattice type of girder take more or the same overload as the box type.

J. A. Jackson: Being a representative of an electrical manufacturer, I do not feel competent to discuss in detail the papers on crane construction which, if I understood them correctly, emphasize the importance of saving weight without sacrificing strength. I do, however, wish to add one general comment. In a paper presented by me before the A. I. S. E. in 1940, advocating smaller bridge motors and larger gear ratios, I ended with the following paragraph: "Experience in any mill operation is an excellent asset, but when the time comes to make an economic study to determine whether the operation of a certain machine justifies its initial capital investment, a mathematical investigation is an invaluable aid to experience and may reveal facts which experience overlooks." The economic study referred to in that paragraph is well exemplified in these papers, and if a saving in weight decreases the cost of the crane, it may offer possibilities for a further cost reduction in the electrical equipment, since the size of the bridge drive is a function of crane weight. It must be continually borne in mind that the mere movement of material from place to place adds nothing to its intrinsic value, in contradiction to a processing machine; hence it is important to keep the cost of material handling machines to a minimum.

As for Mr. Posselt's paper, I have only favorable comment for it. It is based, presumably, on the control scheme now in general use on two-motor bridge drives, which scheme may be considered nearly standard. His presentation of the unbalanced loads which may occur by means of speed, torque and current curves is certainly the most logical and accurate way to show what happens from unbalanced resistors or improper sequencing of contactors. Tests will check the calculated results very closely.

Obviously, Mr. Posselt had to make certain theoretical assumptions in resistance values and relay adjustments. He will no doubt agree, however, that the selected conditions may not be correct for two different cranes or even for two different load conditions on the same crane; hence the per cent unbalancing shown on Mr. Posselt's curves is indicative of what happens but is accurate only for the specific assumed conditions.

Resistance and relay adjustments on bridge motions are at best a compromise which fits operating conditions over only a small range of loads and rope lengths. For other conditions the operator must use judgment in the speed with which he moves the master switch handle.

Member: I would like some information as to the application of horizontal stiffeners.

E. H. Windolph: In regard to the placing of horizontal stiffeners, I would recommend the January, 1940, issue of the American Society of Civil Engineers publication. Also, you can get a copy of the A. I. S. E. Crane Specifications. Also, you can get a handbook published by the Aluminum Company of America. In fact, I think it was the Aluminum Company of America that devised the use of horizontal stiffeners. You can also get a number of volumes on elastic stability problems which are of further aid.

I will say this: the writer's company did experiment with the use of horizontal stiffeners even before the article in 1940, although we did not realize the work necessary to adjust the spacing of horizontal stiffeners or the size and relationship of the stiffener to the web plate when both shears varied.

I would like to answer Mr. Farrington's question in regard to overloading girders. When you buy a 50-ton crane, naturally you get a 50-ton crane and it can be overloaded; the amount depends a great deal on the load and length of span. If you take a crane with a short span, the dead load moment is small and the live load is large. The number of wheels driven is important. In a 4-wheel crane with all wheels driven, stopping that crane with two brakes, exerts a lateral force that is equal to 20 per cent of the weight of the crane and load. If you take this crane, and release the brake on one side, you reduce the lateral moment and increase the capacity of that crane.

With a long span crane, you do not increase the weight of the crane by overloading, and the only increase in moment is caused by the additional lifted load. You may find the moment from the complete crane may equal the moment from the live load, so the overload then can be considerable, and by careful handling you may approach a stress within 4000 to 5000 pounds of the yield point for ordinary steel.

Since you are the owner of the crane and watch its operation, you have the right to increase the capacity of the crane at times, but that should not be a general operating condition; and if you do, you should consult the crane manufacturer and tell him your problem, and he can probably tell you to what extent, with a reasonable degree of safety, you can exceed the capacity of that crane.

F. E. Kling: Mr. Shepherd has covered his subject very thoroughly and I am in accord with his deductions and recommendations. Lattice girder construction results in a much more rigid bridge, especially in the horizontal plane, than box girder design, with less dead weight to accelerate and decelerate and wear out the machinery and crane runway.

High tensile steels can be used to better advantage with lattice design than with box girders, especially on long spans.

For spans from about 70 ft on up, and light to medium capacities, the lattice girders are of definite advantage. For heavy loads and long spans, single web main girders and lattice auxiliary girders are better than box girders.

Cranes as well as any other traveling equipment should be made as light as practicable without sacrificing strengths, which can be accomplished by correct design and use of proper materials.

C. S. Shepherd: Mr. Farrington inquired as to how the cost of the lattice girder compares with the box girder; also as to the relative ability to withstand overload. Overloads are something we have come to accept as normal conditions. As far as cost is concerned, considerable savings can be effected by the use of lattice girder construction. Mr. Jackson has covered that to some extent in his discussion. It is a fact that savings can be effected not only in the initial cost of the crane, but in the cost of runways, motors, bearings, and so on. As far as deflection is concerned, and from the standpoint of taking out the camber of girders, it is possible to overstress a truss as well as a plate girder, although it will probably stand an overload without a permanent set. I am not quoting any figures, but would make the general statement that a lattice girder will withstand more overload with less permanent set than will a box girder.

Cold Roll Forming

. . . . cold forming in continuous mills offers considerable economy over hot rolling methods for the production of many shapes . . . . its increased use is expected in the post-war era . . . .

by C. M. Yoder, PRESIDENT

THE YODER COMPANY

CLEVELAND, OHIO

▲ THE subject of cold roll forming of structural shapes is of increasing interest these days because of the more general application of these methods, in production — and their use will continue to grow. I shall not attempt to predict how many steel buildings will be built after the war, or how many trains, ships, automobiles, airplanes, refrigerators, washing machines or other articles will be made of metal. Neither will I give a long description of the method of cold roll forming. The progression of forming as the metal passes through the forming mill is well known. The size of mill and number of spindles or sets of rolls required are determined by the complexity of the cross section to be formed, as well as the thickness of metal used, and these forming mills are made in standard sizes like other machine tools. Only the roll equipment is changed to roll form the various shapes desired.

In the days gone by when structural shapes were either bolted or riveted together, and production was not so large, sharp corners and rough finishes were accepted by the trade. Today we are welding these parts together, and forming and curving them in large production on machinery; but to do this successfully, the metal thickness must be perfectly uniform or the parts will not be formed or curved uniformly enough for assembly without costly hand work. Present day competition will not permit this slow and costly hand work of refitting. The material must be supplied to the fabricator more uniform in thickness than has been possible by either the extruded or hot rolled methods.

The web or wall thickness of the hot rolled sections, such as angles, channels, tees, etc., are not uniform. They are much thicker at the base corner than the outer edge of the flange. This varying thickness and the lack of uniformity of the metal throughout the sections make them very difficult to fabricate economically by the new welding processes, and the rough scaly finish with sharp corners will not be satisfactory for finished products.

During the war period, most manufacturers have greatly increased their plant capacity. This increased capacity in postwar activities will make competition exceedingly keen, and sales will be made largely on appearance of the article, regardless of whether the article is a truck, railroad car, automobile or household appliance.

Recently I was talking to a group of men from a large concern that makes large line pipe and well casing. This type of material is placed under the ground and is never seen by man after it is installed, and has always been considered rough and ready material. Yet these producers stated that, in their opinion, the finish of line pipe and well casings would largely govern the sale of them, and that they were preparing to use material and methods of manufacturing that would give a mechanically perfect pipe, both in roundness and with a finish that would stand "high light" inspection.

Now, if the finish and appearance of articles like line pipe and well casing, that will be used under the

Presented before A. I. S. E. Pittsburgh District Section Meeting, March 13, 1944.

ground and out of sight, is going to play such an important part in sales, how much more important are the lines and finish on those things that we use and see and have around our homes all of the time.

The steel industry is going to have competition such as they have never had before, not only in household appliances, but throughout all lines of industry, including railroad equipment. The production of aluminum has increased from 327,000,000 lb in 1939, to 2,100,000,000 lb in 1943. Magnesium is now in large scale production with an unlimited source of raw material. Plastics are coming into general use, and many non-ferrous metals such as copper, brass and stainless steel, all capable of having fine smooth finishes, will all be thrown into keen competition with steel mill products.

The strength and light weight of these competitive materials will insure them an important place in the field of manufactured articles and must not be considered lightly by the steel industry, as weight will be a major consideration.

Some time ago a survey was made which stated that up to 75 per cent of the cost of erected structural steel in buildings, bridges and the like was in transportation and handling; this percentage included making the steel, as well as fabricating and erection. Whether this percentage is correct or not, we all know it is a very major item. Therefore, weight itself is an important item and must be carefully considered.

There is no doubt that the ordinary low carbon steel will fast be eliminated from most production, especially where weight and strength are important. For instance, where low carbon hot rolled structural steel is used in bridges, more than one-half of the weight of the entire bridge is required to carry the dead load of the structure itself before any live load is figured.

By using alloy steel that is at least ⅓ stronger than low carbon steel, ⅓ of the dead-weight load of the structure can be eliminated. Then by the use of cold roll formed structural shapes, which furnish the maximum strength at a minimum weight, another large percentage of dead load can be eliminated.

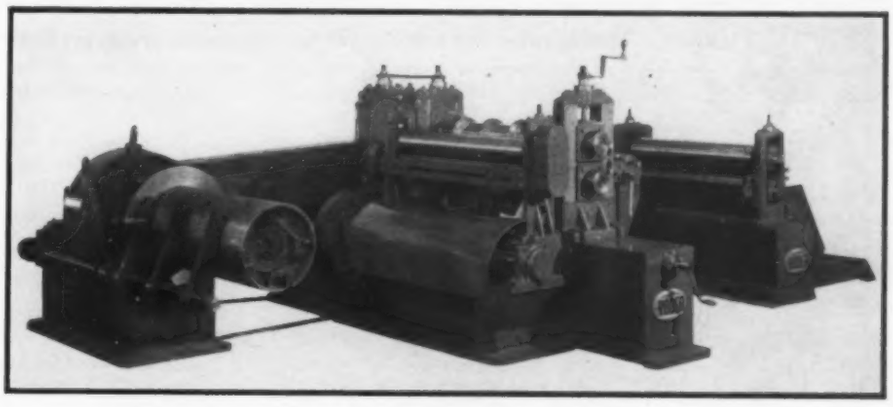


Figure 1 — Multiple slitting line for medium weight steel.

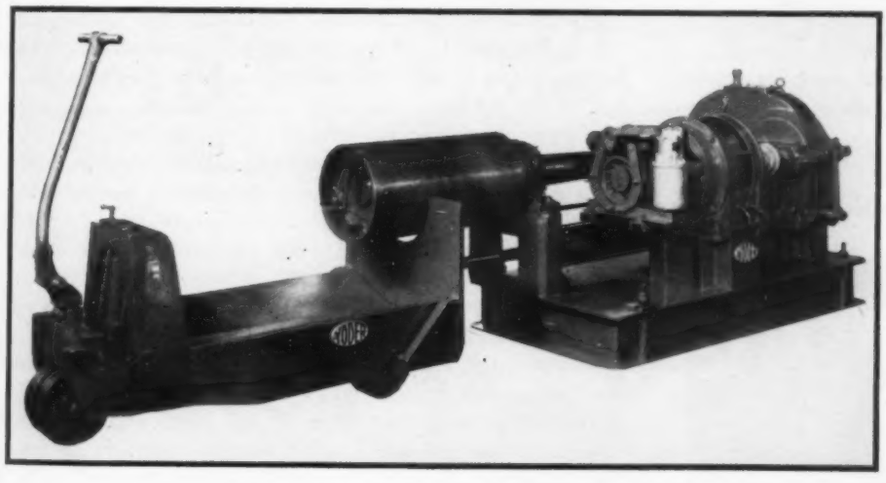


Figure 2 — Collapsible recoiler drum with hydraulic pushoff.

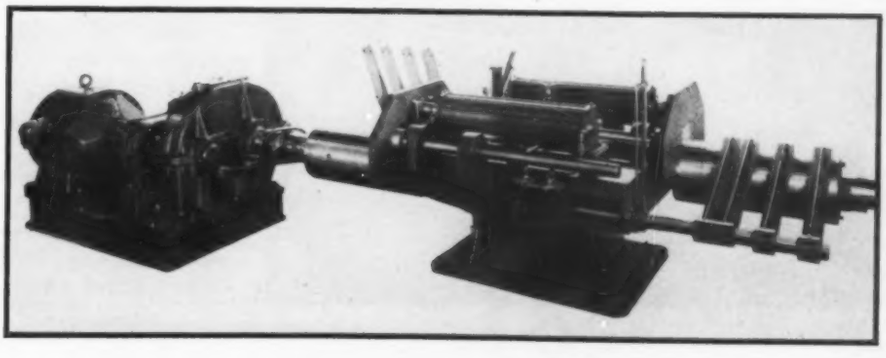


Figure 3 — Double end collapsible drum recoiler with hydraulic pushoff.

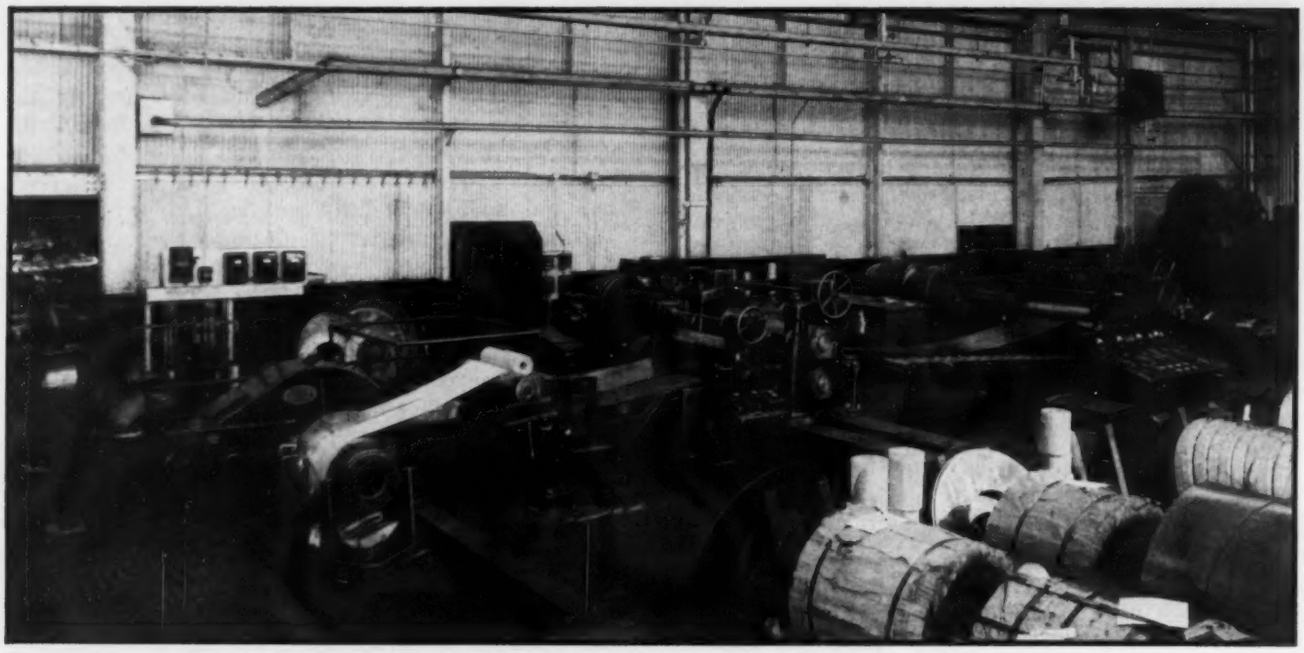


Figure 4 — This slitting line a device for feeding protective paper between the layers of the coil.

We must carry the thought of weight, strength, design and finish throughout our industrial thinking.

How can the steel industry meet this competition? The answer is: By taking the flat rolled steel, either hot or cold rolled, as produced by the continuous mill in coils, slitting it into the required widths by multiple gang slitters, and then cold roll forming these coiled strips into the required structural shapes.

For the safety of the workman handling and erecting structural shapes formed from slit-edged material, the material should be edge-conditioned to remove the sharp edges produced by the slitting shear. This edge-conditioning is done in the forming mill without additional cost. There are other times when it will be advantageous to trim the edges of the metal as it is being formed into shape. This can be done in the forming mill without an additional operation or additional cost. Both shearing and edge-conditioning may be incorporated into the forming mill with no additional operating cost.

Figure 5 — Shop view of slitter and oscillating scrap cutter.

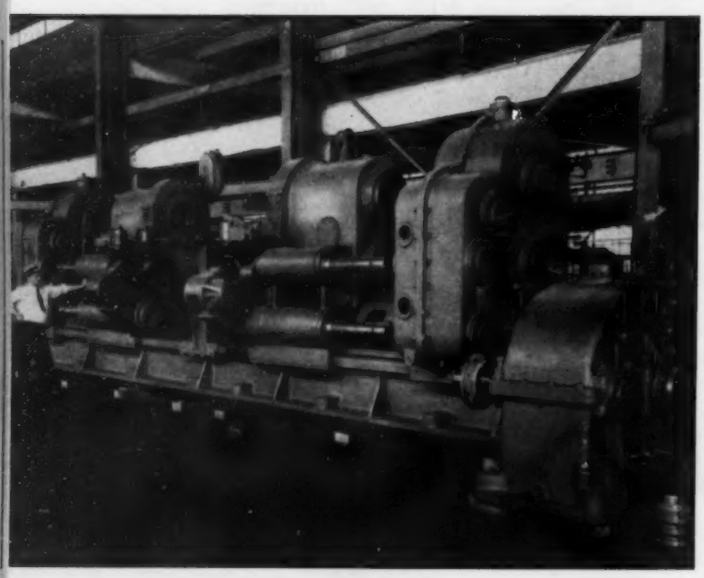


Figure 1 shows a typical multiple slitting line for medium weight steel. The coil of metal is placed in the coil box at the extreme right. The metal then passes through the three-roll leveler that straightens the coil curve, and on through the slitter to the collapsible recoiler drum. The edge scrap is cut into short pieces by the scrap cutter mounted immediately to the lower left of the slitter.

Figure 2 shows a collapsible recoil drum with a hydraulic pushoff attachment operated in conjunction with a coil buggy. This buggy is installed beneath the recoil drum in lowered position. When the multiple sheared strips are recoiled, the platform of the buggy is raised to relieve the weight of the material on the drum as same is collapsed and the coil of metal pushed off the drum hydraulically into the buggy.

Where high speed production is required, a double end collapsible drum recoiler (Figure 3), equipped with hydraulic pushoff may be used; the arms shown at the drums are placed in contact with the multiple sheared coils of stock, to prevent uncoiling when the end of the coil leaves the slitter. When the metal is recoiled on the drum that is connected to the driving mechanism at the left, the drive clutch is released and the recoiler is revolved 180 degrees, and while the loose end of each sheared coil is securely held, it is then wired and removed from the drum while the other drum is being filled. Similar double uncoiling drums are also provided for this type of arrangement in a slitting line.

Figure 4 shows a little different arrangement of a slitting line. This line consists of a coil box, a leveler and slitter with scrap cutter, a protective paper feeding

device, a collapsible drum recoiler and coil buggy with hydraulic pushoff below the floor level. The average tonnage per 8 hr of shearing and recoiling is from 150 to 250 tons, depending upon the gauge of steel and the width of coils.

Figure 5 shows the slitter and scrap cutter on the shop floor, practically completed. With this slitter and oscillating type scrap cutter — in the first thirty days that this slitter and oscillating scrap cutter was in operation, 31,000 tons of ¾ in. steel plate was sheared and the scrap cut into short pieces.

The forming mill shown in Figure 6 is used very extensively by the aircraft industry for cold roll forming the inner struts and bracing of the airplane. It is equipped with both edge-trimming and edge-conditioning attachments. The trimming cutters are mounted on the first pair of shafts with a scrap baller that is power driven and mounted at the top of the mill. Forming mills may be equipped with a scrap cutter instead of a scrap baller if desired, mounted under the trimming shears at the front or feeding end of the forming mill.

The edge-conditioning attachment is mounted between the trimming shear cutter shafts and the next pair of horizontal shafts. This arrangement provides that either one or both of these attachments may be used at the same time. Provision is also made for releasing these attachments, and they may be left in place on the mill, but not used, and stock can be formed on the mill without either being trimmed or edge-conditioned.

Figure 7 shows a forming mill with automatic shear cutoff. The material shown is a hinge section used in automobile hoods. These sections must be formed exceedingly accurately, as one section of the hinge must rotate inside of the other the entire length of the automobile hood without distortion or rattle, and at the same time, not bind, but work free under all conditions to which an automobile is subjected.

The forming mill shown in Figure 8 is equipped with an automatic saw cutoff as shown, and is forming a shade roller tubing. The groove in the side is formed in the tube to permit attaching the curtain shade which has a rope sewed at the end where it attaches to the

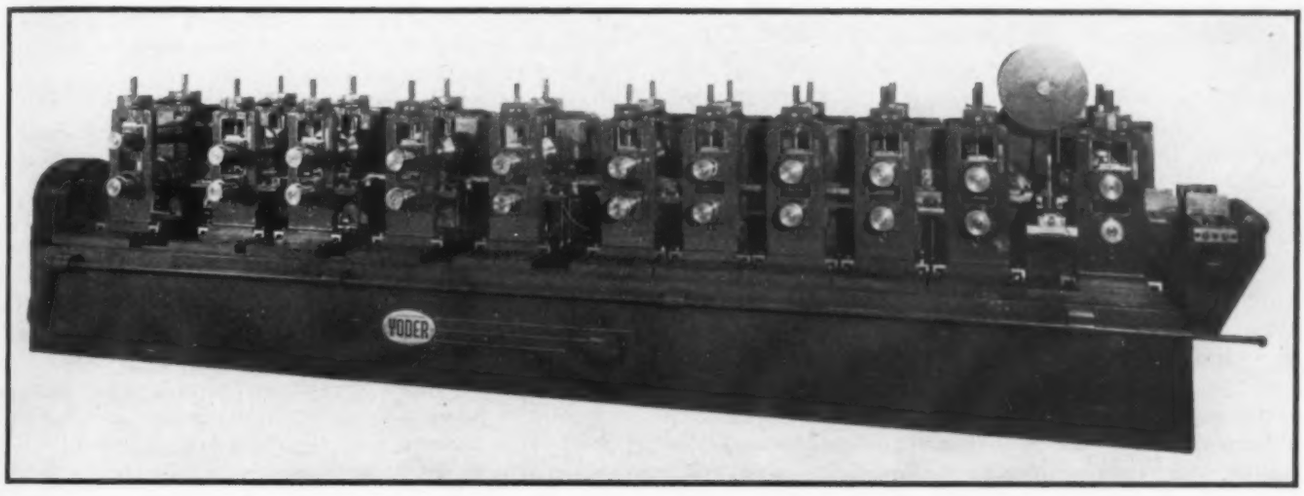
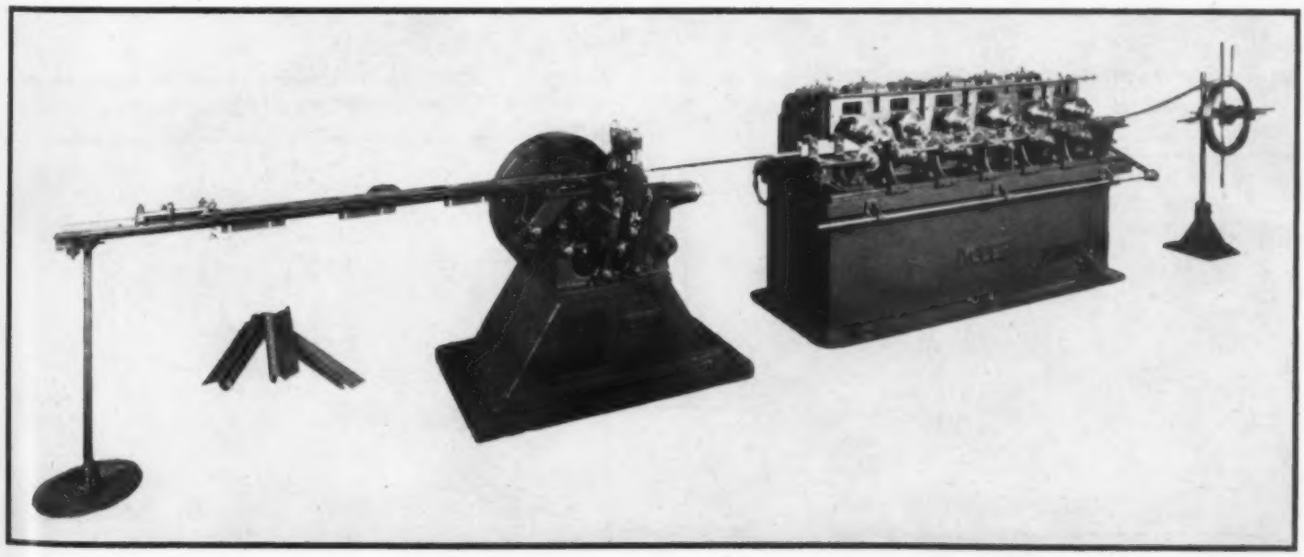


Figure 6 — Mill widely used for cold roll forming inner struts and bracing for airplanes.

Figure 7 — Forming mill with automatic shear cutoff. Enlarged pieces of section formed are shown at the left.



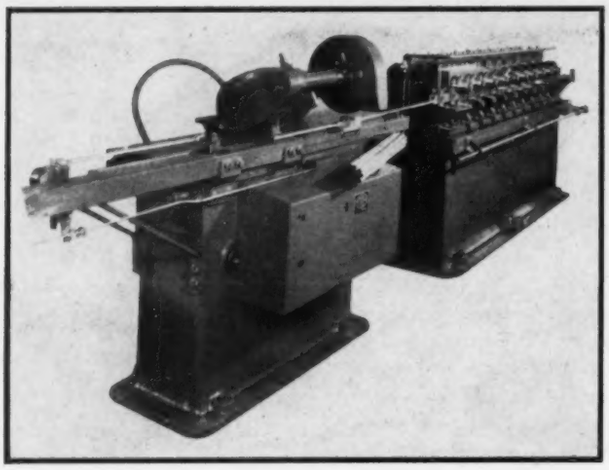


Figure 8 — Another forming mill with automatic saw cutoff, used in forming shade roller tubing.

roller. This tubing is double seamed and cut to the required length with the automatic saw cutoff. This tubing is produced and cut to the desired length at about 80 fpm. One man operates this unit.

In Figure 9 we show here a little different setup for forming a continuous piano hinge. The stock is fed from the coil to the first machine at the right which notches or pierces the strip continuously and very accurately. It is then fed through the forming mill that forms the hinge complete, then passes through the shear cutoff that cuts it to the exact required length. This line is completely automatic and produces at the rate of 60 fpm.

The piercing machine at the extreme right of Figure 10 accurately blanks two slots crosswise of the strip at predetermined spaced intervals. This pierced strip passes continuously through the forming mill, where it is formed into a tube with the edges double seamed, making a tight seamed tubing of clover leaf design.

Many other shapes and designs may be formed with the proper roll equipment. From the forming mill, the partly severed seamed tube passes through the final cutoff. Note that this final cutoff cuts the tube off horizontally without distortion or burr, at a speed of 30-60 and 90 fpm, according to the length of the pieces required; many of them are as short as 7 inches.

The cold roll former shown in Figure 11 is equipped for making tank sections for tanks such as are used in the oil fields. The sections are transported to the new fields and erected into large tanks to store crude oil. In the detail of Figure 12 the steel plates are pierced with two rows of holes along the sides and across the ends, while the material is in the flat plate, as shown at A. Then as the pierced plate passes through the forming mill, each edge is folded over upon itself, as shown at B. The inside row of holes should be approximately 1/16 in. larger than the outer row of holes to allow for a slight variation in the forming process. As the sheet continues through the forming mill, this double formed edge is flanged at a 90 degree angle, as shown at C, and as the flanged section passes the last set of rolls of the mill, it is curved to the predetermined radius of the assembled tank. D shows how these sections are bolted together in assembling the tank. These tanks are assembled with bolts, so they can be taken down and moved to a new field.

Figure 13 shows a mill arranged for forming light gauge metal into siding, roofing and other purposes, while Figure 14 shows some of these sections cold roll formed at the rate of 150 to 200 fpm.

The automatic piercing, forming and cutting off line illustrated in Figure 15 is adapted for making double hung window sash and window frames. The metal taken from the coil passes through the first machine at the right, which pierces and partially severs the flat steel strip as it continues on through the forming mill and to the final cutoff. By this method of piercing and partially severing the steel strip while it is still in the flat, it is possible to make the final cut off with a single acting die. Much time and many expensive dies and numerous operations are thus saved in contrast with a method of fabrication where the window sections are completely formed and then severed in complicated and expensive dies in a press.

In the production of this material, there are seven separate sections. The roll equipment and the piercing and cutoff dies must be changed for each section. The production from this one line is from 10,000 to 12,000

Figure 9 — Another forming mill used for forming a continuous hinge for pianos.

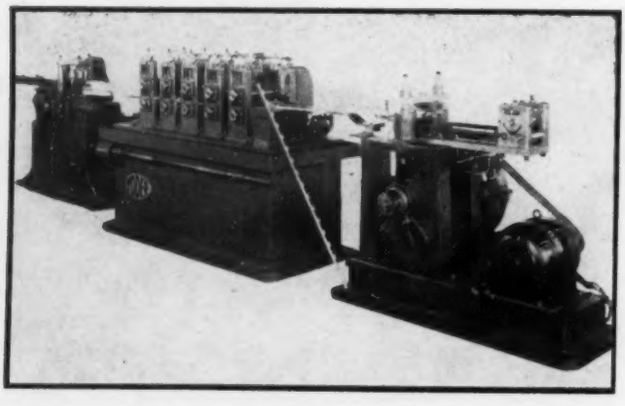
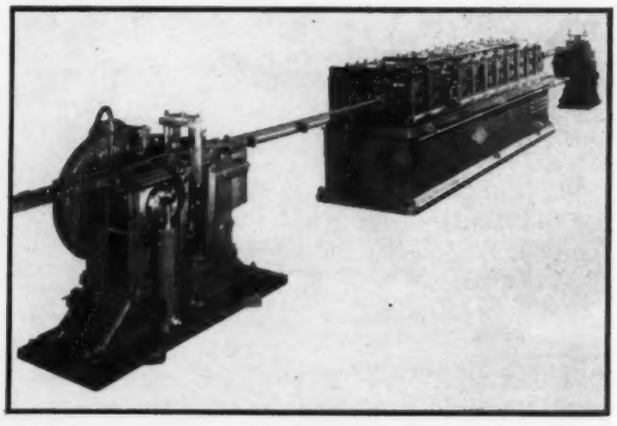


Figure 10 — Forming mill which produces tight seamed tubing of a clover leaf design.



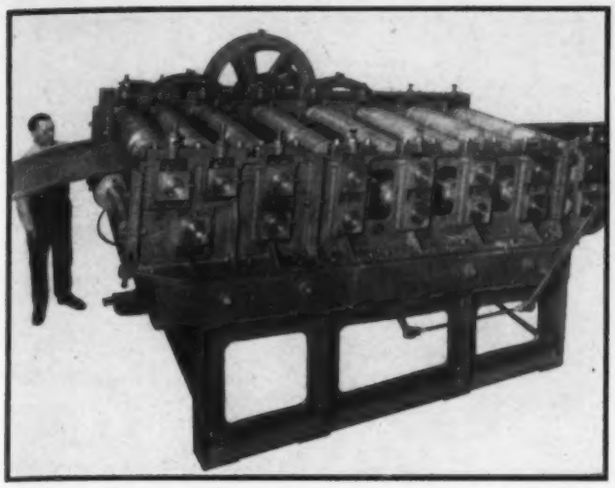


Figure 11 — This machine makes sections for tanks such as are used in oil fields.

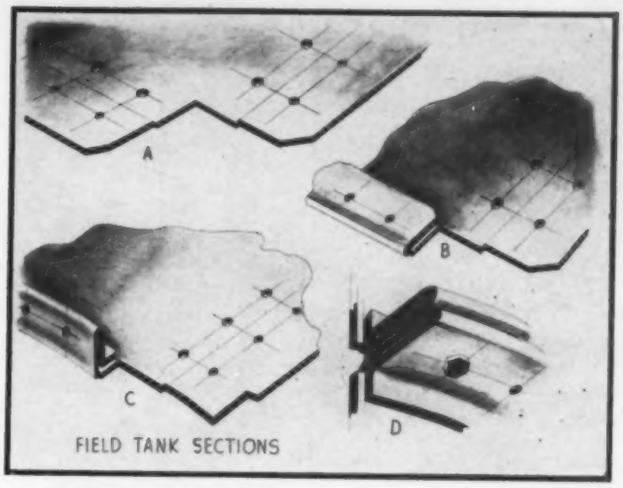


Figure 12 — Details of the steps in forming tank sections.

complete windows and window frames per month, averaging over a period of several years. Figure 16 illustrates how the flat stock for one of the seven sections is pierced, and also how these sections are assembled after the final cutoff.

Figure 17 shows a type of forming mill for medium weight structural shapes. One of these mills was delivered in February, 1928, and has been in constant use ever since. In 1942, 6349 railroad carloads of airfield landing mat sections were formed, and the edges simultaneously trimmed to sheets 19 in. in width from No. 10 gauge stock. In 1943, 15,652 tons of the same material were formed; 100 tons were formed in one eight-hour shift. This indicates the long life and the diversified use to which these roll forming mills can be adapted.

A mill that will form structural and special shapes up to ½ in. thick plate is illustrated in Figure 18.

One of the most advantageous features of the cold roll forming method of production is the adjustability of the rolls for producing structural sections, and also the ease in which these rolls may be changed from one thickness of stock to another, as well as in changing the size of sections. For instance, in Z bars having webb sizes from 1¾ in. to 12 in., and wall thicknesses from 1/16 in. to ½ in., are formed on one set of adjustable rolls, and not only can the size and wall thickness be changed, but also a wide variety of steels, such as alloyed steels, low carbon and high carbon steel, may be formed on this same set of rolls. Just as wide a range of stock and varying thicknesses and sizes can be used in forming angles, channels and similar shapes by the use of sets of adjustable rolls (Figure 19).

The wide variation of sizes we have mentioned is given only to indicate the versatility of the cold forming mills, and also the possibilities of the adjustable roll combinations. We do not recommend, however, that one forming mill and one set of rolls be used for such a wide range of sizes for economical production, for the reason that a mill large enough to roll form ½ in. thick plates would be too cumbersome and costly to operate for forming the lighter weight and smaller sections.

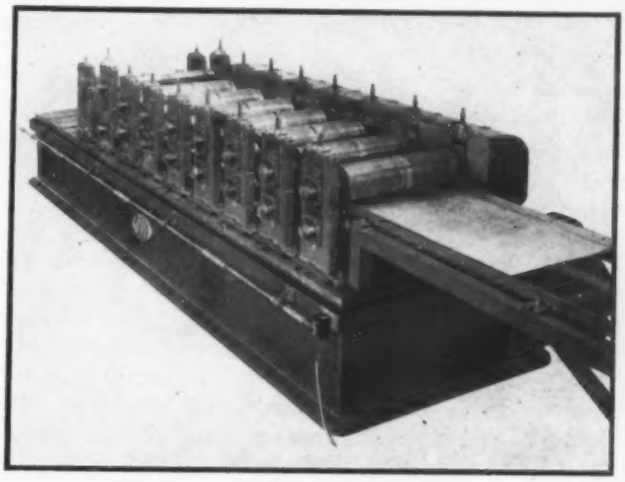
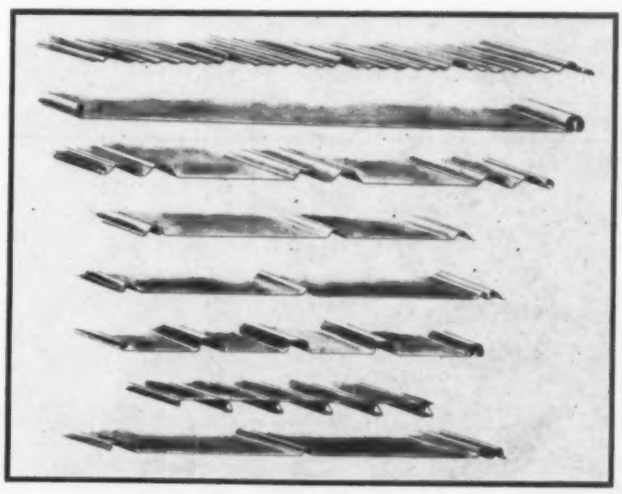


Figure 13 — Cold forming mill for forming light gauge metal.

▲

Figure 14 — Some of the sections cold roll formed in mills such as shown in Figure 13.



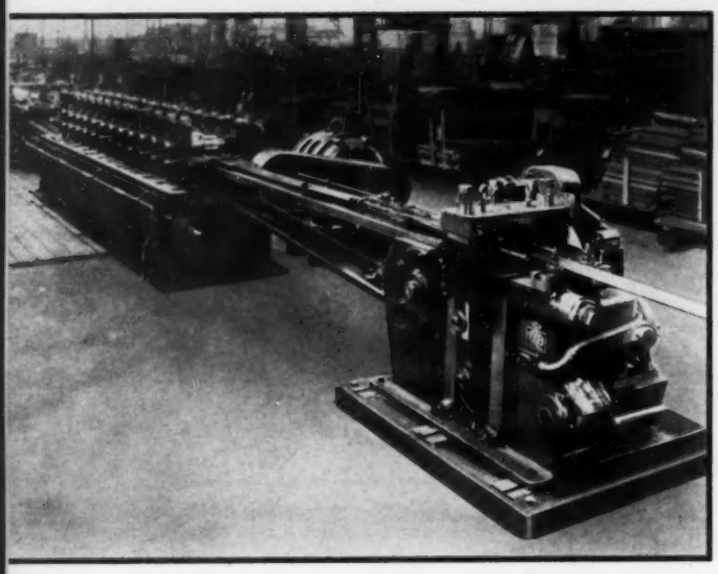


Figure 15 — Automatic piercing, forming and cutting off line for making window sash and frames.

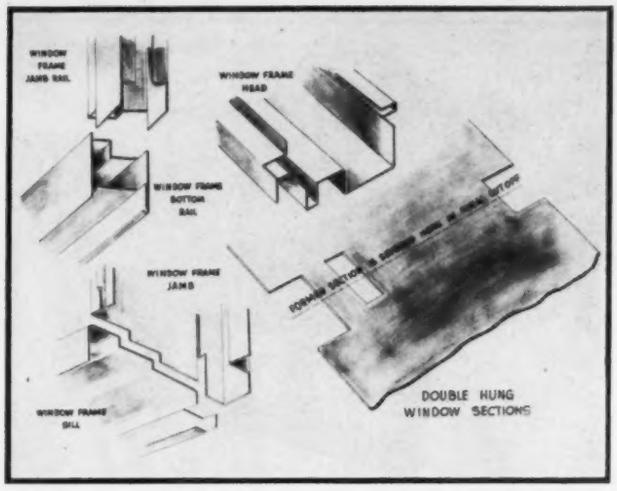


Figure 16 — Details of one of the window frame sections formed in the line shown in Figure 15.

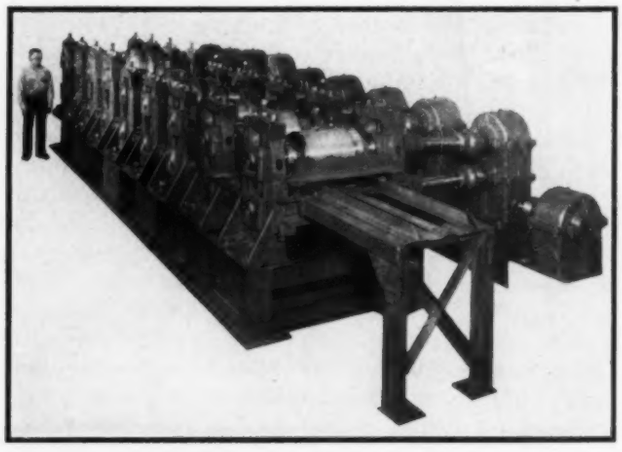
The accuracy of the cold roll forming method of production of structural shapes is illustrated by the perfect 90 degree angles remaining in the sections, even after cutting to very short lengths. This proves that the strains are relieved, so that when they are cut off as short as several inches in length, they do not distort or change their shape. Lengths running in continuous production up to 100 ft lie perfectly flat and straight, without wind or twist. No subsequent straightening or reshaping of any kind is required in the manufacturing of cold formed shapes. They are ready to be shipped to the job as they leave the forming mill.

Angles from 5 in. x 5 in. x $\frac{3}{8}$ in. to 6 in. x 19$\frac{1}{2}$ in. x $\frac{1}{2}$ in. have been formed on one of these mills equipped with adjustable rolls, with a conversion cost of approximately $1.00 per ton. This $1.00 per ton includes factory overhead; 475 to 500 tons constitute an eight-hour shift production.

Special sections, such as required for roof decks and the like, are cold-roll-formed by taking the steel from the coil, forming and automatically cutting off the formed section to the exact required length ranging from 7 ft to 50 ft, and widths of finished sections 6 in. and 12 in., at a speed of 80 to 140 fpm.

Electrically welded pipe and tubing is fast taking its place in practically all branches of industry where pipe and tubing is used. The facilities for manufacturing electric welded pipe have improved so much in the past decade that it is now practical to weld stainless steels, high carbon steels and other alloy steels, as well as the ordinary carbon steels.

In the older types of welders, the current controls were very inefficient. Where you find the transformer permanently mounted at the top of the machine, above



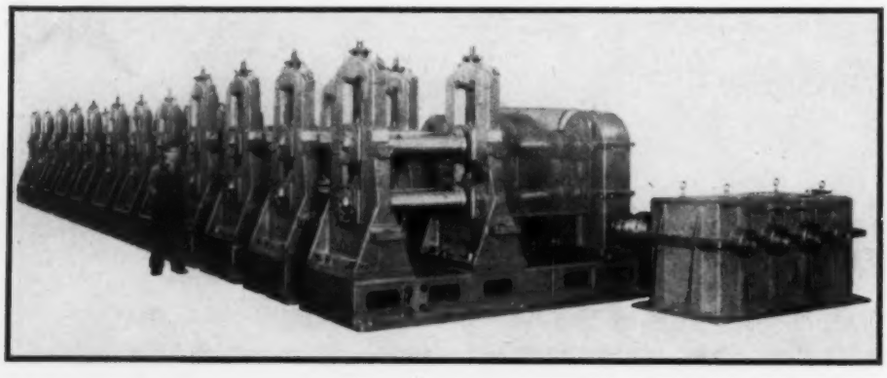


Figure 17 — Mill for cold forming medium weight structural shapes.

Figure 18 — This mill will cold form structural shapes from plate up to ½ in. thick.

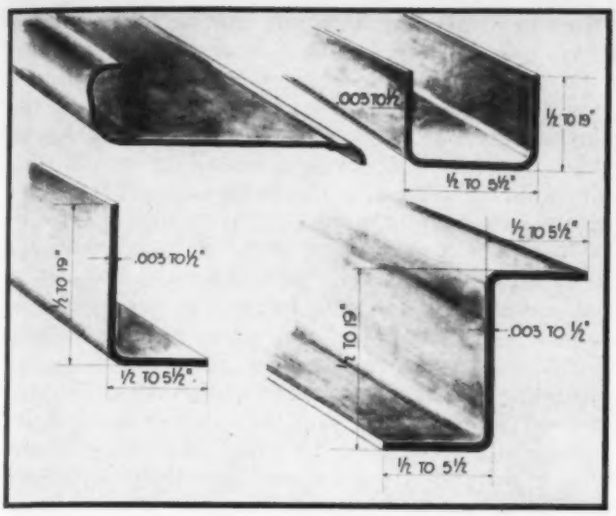


Figure 19 — Ranges of some of the sections cold formed in adjustable rolls.

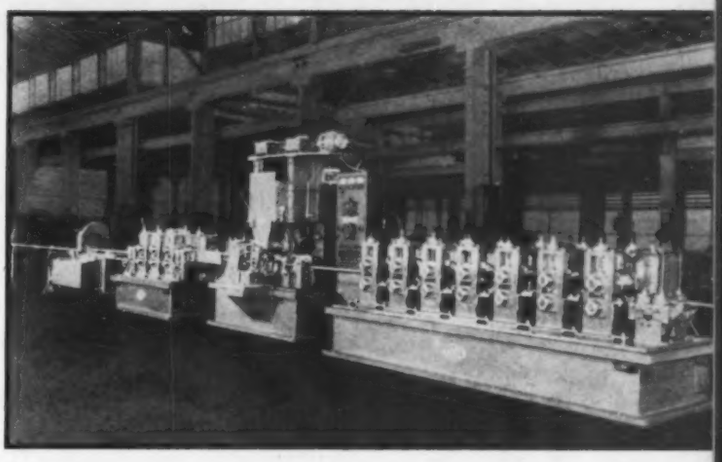


Figure 20 — Cold forming line for tubes, with electric welder having its transformer mounted remote from the welder.

the electrode shaft the low voltage current (usually from 4 to 6 volts) is compelled to travel through a long secondary circuit from the transformer through a series of brushes to a commutator on the electrode shaft and to continue on to the outer edge of the electrode, where it finally contacts the pipe and then returns to the same distant transformer.

This long secondary and brush contact arrangement caused the welder to be quite inefficient. The efficiency rating of this type of welder is usually below 50 per cent. It must be very obvious to everyone who is familiar with electric welding that in any type of welder where less than 50 per cent of the energy is utilized (especially where current of so low a voltage is used) it is very difficult, if not impossible, to hold a perfectly uniform welding heat for resistance welding on a production basis.

With the new design of resistance welder, the transformer is firmly attached to the electrode hub, which is a large mass of low resistance copper that permits this low voltage current to pass through with the least resistance to the outer edge of the electrode, where it contacts the pipe at the point of welding with practically no loss of current, as brushes and all other movable or sliding contacts are eliminated. This arrangement provides a very short secondary, since the transformer rotates with the electrodes. This welder is over 90 per cent efficient, and with ample provision for the control of the current, a weld that is practically 100 per cent efficient is produced commercially in day in and day out production.

Figure 20 shows the arrangement of an electric welder, as has been previously described, with its transformer mounted a distance from the welding area, and also with its long secondary circuit and its sliding friction brushes that result in the great losses in the low voltage welding current.

Figure 21 shows a complete pipe making unit. The flat steel enters the forming mill from a coil box (not shown) at the right. The edges of the steel are prepared for welding, and the pipe formed in the cold roll forming mill. The formed pipe then passes directly into the welder. The welding bead is trimmed off as the pipe leaves the welder and passes on through the cooling tank to the sizing and straightening mill and the automatic rotary cutoff in one continuous operation.

Figure 21 — Complete unit for making electric welded pipe.

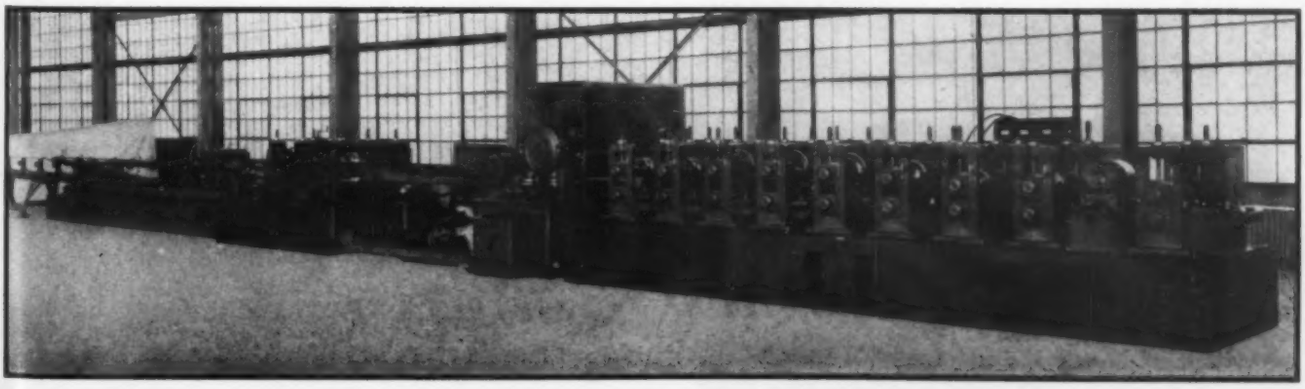


Figure 22 — Shop view of part of a tube line, using an atomic hydrogen welder and a resistance welder.

This unit will accommodate up to 4 in. standard pipe.

Figure 22 shows only a partial tube line. It shows two welders in the line. The one at the right is an atomic hydrogen welder, used where stainless steel or high alloyed steels are welded. Speeds from 10 in. to 90 in. per minute have been attained on this welder. The resistance welder is shown next in line and is used on carbon steels. Using 60 cycle a-c, speeds up to 105 fpm have been attained on this welder. Both of these welders are permanently installed in line, so that when stainless steel is welded the resistance welder electrodes are adjusted upward and out of contact with the pipe. Only a slight adjustment is required to use either welder.

Pipe in short lengths is often required, especially in the smaller diameters. In this event, the pipe is cut off in longer lengths in the tube mill cutoff, then conveyed to a multiple cutoff and cut into the exact required length in one operation.

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INDUSTRIAL FURNACES

New developments and improvements are constantly being made in materials, as well as in the methods of working them. We were told that some of the aluminum alloy clad metal could not be formed. However, this material has been roll formed, as have the magnesium alloys. Stainless steel having a tensile strength of from 180,000 to 200,000 psi is also being cold roll formed in high speed production.

I have endeavored to set forth a few facts concerning the trend of manufacture using steel as produced by continuous mills, and cold forming it into structural sections; and to indicate what a tremendous saving is effected in conversion costs over the well known hot rolled shapes. I do not wish to leave the impression that cold roll forming will completely replace hot rolling. I am firmly convinced, however, that the cold roll forming method will play an increasingly important part in post-war activities.

Ramseyer PAPER

(Continued from page 44)

25¢ per 1000 cu ft, including fixed charges. This means that the total cost of the reducing agent will be approximately equal to the cost of the coke used in a blast furnace, or around $5.00 per ton of product. However, the whole operation will be simpler than the production of pig iron in a blast furnace.

The operation is a low temperature one. The fine ore merely needs to be delivered by a pipe line to the top hearth of the furnace. During the reduction no coke, limestone, or molten materials have to be handled. The problem of the distribution of the charge in the shaft, which is an item of major importance in blast furnace operation, no longer exists. The finished briquetted sponge iron comes out continuously from the bottom of the reducing unit. In fact, the process from beginning to end is 100 per cent continuous. The problem of material handling is also greatly simplified compared with the blast furnace. We believe that on a comparable scale the operating cost for labor and maintenance should not be more than one-half to two-thirds that found in blast furnace practice. Similarly, the capital cost of a 1000 ton per day plant, including the hydrogen plant, is not expected to be more than two-thirds that of a complete blast furnace and coke plant of the same capacity.

The low temperature gaseous reduction of iron ore has great possibilities. Its only limitation is that it requires a relatively pure ore, preferably one containing not more than 2 per cent or so of silica. Probably not more than one-third to one-half of the world's iron ores are or can be economically concentrated to this degree of purity, so that there is no question of this new process displacing the blast furnace. It is the writer's opinion, however, that where suitable ores are available, particularly those that have to be finely ground anyway for concentration, this new process will prove to be more economical than any other. Also, since it is not dependent on metallurgical coke for its operation, it will make possible the production of high quality steel in many parts of the world where it has not been economically possible to make steel.

Improved Control FOR Runout Tables

. . . . modern control systems, using exciters of quick response and low control wattage, give close coordination between drives and production requirements, with a high degree of reliability . . . .

by B. Starie

INDUSTRIAL CONTROL ENGINEERING DIVISION
GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

▲ IN the past forty years, magnetic control for steel mill applications has been perfected to a high degree and has contributed greatly to the increased tonnage of steel produced today. Now, a new system of control has appeared on the scene, involving the use of the amplidyne.

Since the comparatively recent advent of this remarkable exciter, every function of a steel mill control system has come under its influence. Precision, as never before, marks every move from start to stop, the outstanding feature being regulation in all of its applications.

The amplidyne is a motor-driven exciter of unique design, characterized by its extremely low control wattage — a ten-thousandth part of its output — and by the speed of response which is fifty times faster than that of a conventional exciter. The unit may furnish excitation for a small d-c generator in an adjustable voltage system or it may furnish excitation for the exciter of a similar but larger d-c generator.

The exciter fields may have several independent windings, each responsive to some feature of the drive operation. Typical fields are:

1. A field separately excited from a constant potential source to provide output voltage and to determine polarity.
2. An opposing field which measures voltage output of the generator or load on the motor, lowering excitation if voltage or load increases.
3. A field that prevents overshooting of generator voltage from "forcing."
4. A field which limits current to a predetermined value and holds load to that value during acceleration.

RUN-OUT TABLE CONTROL

Perhaps the best way to explain the functions of the amplidyne is to analyze a comparatively simple system in which it is used directly as the exciter in a Ward-Leonard system such as in a run-out table drive. This application to a run-out table of the type shown in Figure 1 provides for the control and regulation of d-c table roll motors connected in an adjustable voltage system.

Referring to the elementary connection diagram, Figure 2, the exciter (EX) is equipped with four control fields:

a. Directional control field to establish polarity of exciter and of generator. Increased strength raises voltage of exciter and generator. This field is excited from an outside constant potential source.
b. Main control field opposed to directional control field. Increase in strength of this field lowers voltage of exciter and generator.
c. Current-limit control field to establish a ceiling on current output of generator. Determines the rate of build-up of voltage during acceleration by opposing

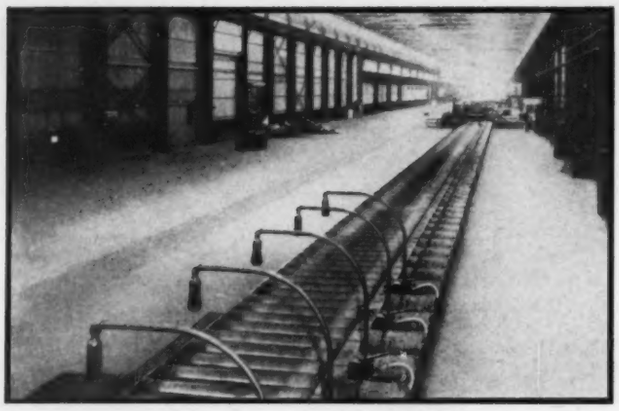

Figure 1 — General view of runout table driven by d-c motors under adjustable voltage control.

the action of the directional control field (a). Determines the rate of voltage decay on deceleration by opposing the action of the main control field (b) after disconnecting directional control field (a) from its d-c supply.

d. Anti-hunting control field which opposes wide voltage changes and prevents overshooting of voltage. This field is excited only when voltage is changing and in proportion to rate of change.

OPERATION

One or any number of these four fields may be effective at the same time. However, for simplicity the action of each will be described as an isolated event.

Acceleration — Closing the forward contactors (F), first disconnects the directional control field (a) from the armature circuit of the exciter, and then reconnects it to the constant potential line. This produces an instantaneous rise in the exciter voltage, which creates a rapidly rising positive potential at the (A1) terminal of the generator. Since contactor (FV) is now closed, this rising generator voltage is applied to the main control field (b) of the exciter. As the main control field (b) is arranged to oppose the action of the directional control field (a), as indicated by the arrows, the effect of the latter is rapidly reduced, until the resultant or the net effective flux produced by these two opposing fields is just sufficient to sustain the predetermined generator voltage. As either the directional control field (a) or the main control field (b) is capable of producing several times the flux necessary to produce the rated voltage, very effective field forcing is available. Consequently current limit protection is necessary to protect against excessive load current and too rapid acceleration.

Current-limit action — Current-limit restriction does not become effective until a predetermined load is reached. Should the load tend to exceed this limit, current begins to circulate through the current-limit field (c) so that it opposes the "build-up" action of the directional control field (a). The opposing action of the current-limit field (c) is sufficient to hold within the prescribed bounds the load current caused by acceleration.

This current limit, ceiling effect, is obtained by comparing a voltage drop which is proportional to load with a fixed voltage drop, and by allowing current to circulate through the current-limit field only when the load "drop" exceeds the fixed "drop." With generator terminal (A1) positive as prescribed above, IR drop (f-e) due to load is compared with fixed IR drop (f_1-k). When the load increases to a point where load drop (f-e) exceeds fixed drop (f_1-k), rectifier (L) allows a current to circulate through current-limit field (c) in proportion to the voltage difference.

Speed control — Generator voltage or table speed may be raised or lowered by means of rheostat (Rheo.). Reducing the resistance in series with main control field (b) allows stabilization to occur at a lower generator voltage. Increasing the resistance would require a higher voltage for stabilization.

Retardation to stop — Opening the forward contactors (F) disconnects the directional control field (a) from

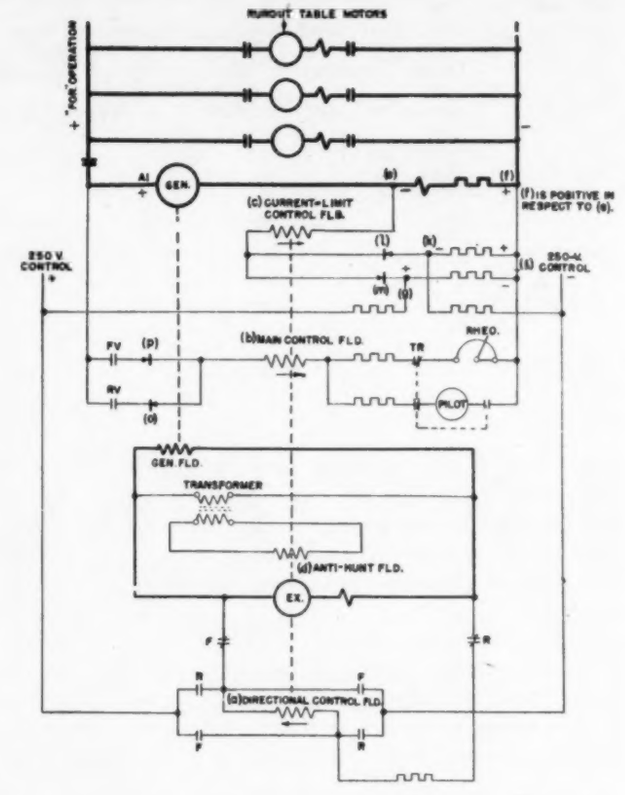

Figure 2 — Elementary connection diagram of a run-out table d-c drive using amplidyne control.

the constant-potential line and reconnects it across the exciter armature. Consequently, the action of this field is now reversed and it acts in conjunction with the main control field (b) to reduce the exciter voltage (contactor FV remains closed). If this action produces an excessive pump-back current due to too rapid retardation' current-limit field (c) now acts in the opposite manner to sustain the generator voltage. Since the pump-back current is in the opposite direction, and load drop (e-f) exceeds fixed drop (g-f_1), rectifier (m) allows current to circulate through the current-limit field in the opposite direction.

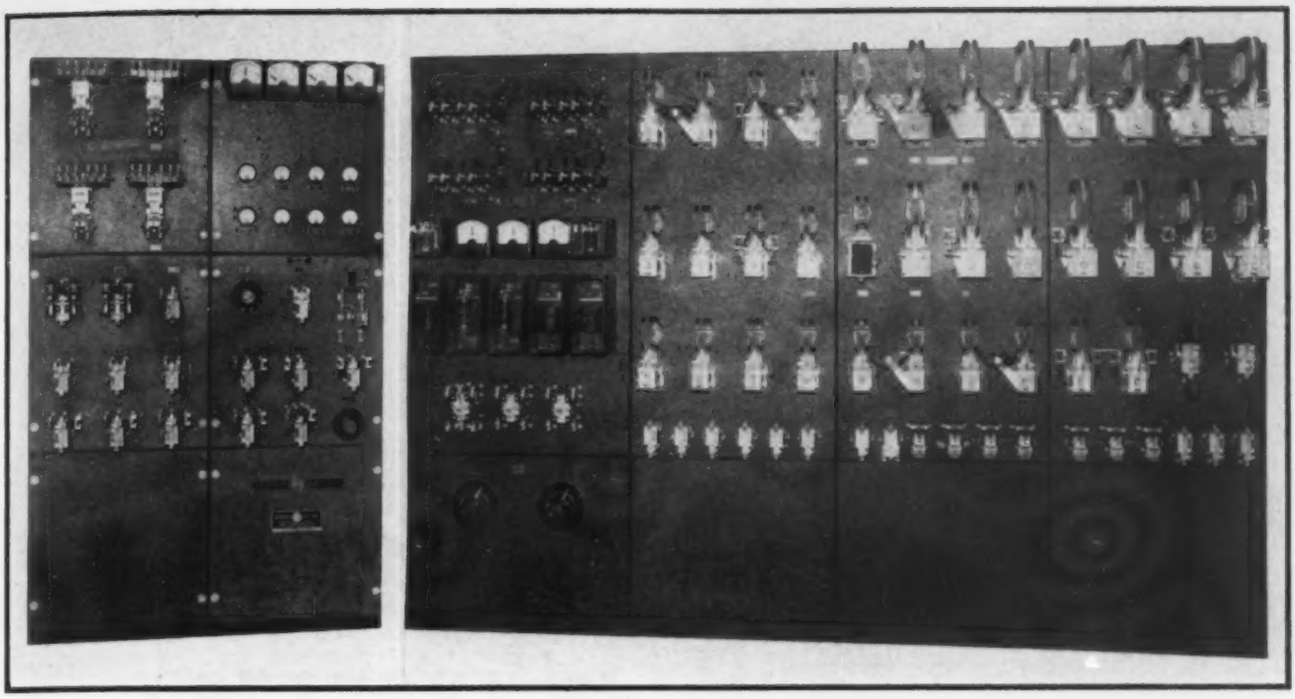

Figure 3 (Left) — Control panel used with the modern type blooming mill control.
Figure 4 (Right) — Blooming mill control panel for conventional magnetic control system.

Plugging — When the drive is plugged, directional control field (a) is reversed. Consequently during the retardation period, it actually forces the generator voltage down. The main control field (b) is made inactive during the retardation period, contactor (FV) having opened, and contactor RV having closed when the drive was plugged. Current is prevented from circulating by rectifier (o) until the generator voltage has actually reversed to start the acceleration period of the plugging cycle. Current-limit field (c) will function automatically throughout the entire cycle, first to limit the rate of retardation by holding the generator voltage up, and second to limit the rate of acceleration by holding the generator voltage down.

Anti-hunting — Because of the effective forcing inherent in the over-excited differential field combination, it is necessary to provide restriction against overshooting of the generator voltage to prevent its rising momentarily above the predetermined value. To accomplish this, a transformer is connected across the exciter armature; the secondary output, available only while voltage is changing, causes the anti-hunting winding (d) momentarily to oppose the forcing action of directional control field (a) during the buildup period. Obviously, this is equally effective when rapidly reducing the generator voltage, except that the action is reversed.

ADVANTAGES

Some of the characteristic advantages peculiar to this type of control are:

1. *Current ceiling* — Instead of the accelerating current being an average of the peak and valley values, it will be sustained at some suitable maximum level above which the current cannot rise. Thus, the maximum possible rate of acceleration is assured.
2. *Constant voltage* — Since the main control field (b) measures the generator terminal voltage, any decrease in voltage weakens this field, thereby permitting directional control field (a) to become more effective until the voltage is restored to the prescribed value.
3. *Speed matching* — Because of the inherent tendency to maintain constant voltage, this control affords an excellent means of matching the table speed exactly with the speed of the material being delivered. Thus, if the output voltage of a pilot generator (pilot) reflects the speed of the delivery stand of the mill, and this voltage is substituted in place of rheostat (Rheo.) and used to oppose the voltage of the generator, the table motor speed will follow every variation of delivery speed.
4. *Less control equipment involved* — Current ceiling, constant voltage, or effective speed matching are all important factors in starting the run-out table motors faster and in keeping their speed adjusted more accurately in order to match delivery speed. With the amplidyne, this performance is obtained with approximately 50 per cent fewer devices such as contactors and relays than is possible with conventional magnetic control equipment. The devices required are also smaller. For example, conventional magnetic control equipments, which include a motor-operated generator field rheostat, have required the use of some thirty contactors and relays, while the new type of control requires only about fifteen. This reduction in equipment is effectively illustrated by Figures 3 and 4. Figure 3 shows equipment for a modern blooming mill with the improved

(*Please turn to page 79*)

Electronics IN INDUSTRY

by C. J. Madsen, ELECTRONICS ENGINEER
INDUSTRIAL ENGINEERING DEPARTMENT
WESTINGHOUSE ELECTRIC AND MFG. CO.
EAST PITTSBURGH, PENNSYLVANIA

. . . . electronic tubes, handling currents ranging from thousands of amperes down to infinitesimal amounts, can amplify, generate, control, transform or convert electrical energy in almost any manner . . . . electronics, however, cannot do everything . . . . care should be exercised to avoid mis-application . . . .

▲ TO many people the word electronics still carries with it the atmosphere of strange imaginary worlds, assorted eliptical orbits, weird atomic structures and other mystifying figures. To others, it conveys radio broadcasting and television. However, to those associated with the science of electronics for over a decade, this mirage is replaced by the mental picture of thousands of electronic devices in every day use in our factories, mills, offices and homes.

There are probably as many definitions of the word electronics as there are individuals associated with its application. One definition is: Electronics is the application of devices in which the flow of free electrons are made to perform such numerous functions or duties as to rectify, amplify, generate and control current, convert light into current and current into light. The necessary tubes may take the form of diodes, triodes, ignitrons, pentodes, beam power tubes, thyratrons, phanatrons, kenatrons, photo tubes, cathode ray tubes and so on. A brief study of the application of these hundreds of types of tubes shows that the science of electronics is not new. It also shows that the future possibilities are extremely important in that hardly a week passes without the development of new tube types or new combinations of tubes and circuits to perform new functions.

Early activity with electronic tubes led to the creation of radio station KDKA, the pioneer of our present day broadcasting. The development of high-power, air-cooled radio transmitters, made possible by high-power, air-cooled electronic tubes, undoubtedly aided in the development of high-power tubes for use in radar equipment. But the activity was not confined alone to the broadcasting field as evidenced by the numerous electronic control devices used in many of our industries today.

The developments of electronics can best be explained by breaking down the applications into these nine classifications:

Rectification
Inversion
High frequency heating
Communications
Measurements
Control
Inspection and sorting
Precipitation
Radiation

Presented before A. I. S. E. Cleveland-Youngstown District Sec. Meeting, Nov. 22-23, '43

There are two fields which have been important in past years in rectification. The first is power rectification. The second, high voltage rectification, is important in that it is frequently employed as a means to an end in many other types of electronic equipment, such as power supply for high frequency oscillators, radar, communication equipment, measuring equipment, and our broadcast receivers and transmitters. Rectification will have an important position in most of the electronic devices which may be developed in the future because of the nature of electronic tubes.

At the present time relatively little work has been done in the use of inversion principles. A few particular applications in the conversion of 25 to 60 cycles and vice versa have been made. However, the use of inversion will become increasingly important to a number of industries in the future as a source of variable-frequency a-c power which provides a means of variable speed control for drives employing a-c motors. It should be extremely useful in the operation of certain high-speed machine tools for variable-speed control.

High frequency heating was the subject of much experimental work more than ten years ago. Experiments were conducted at that time in the heating of various materials such as plastics, bonds, food, metals, cements and for the extermination of bugs and larvi. Excessive cost caused by misapplication or misunderstanding of some of the limiting factors proved some of these applications impractical. However, a number of these applications have been brought to the front recently and will undoubtedly become increasingly widespread in their application in the future.

Some of the present applications employing dielectric heating are the bonding of plywood, and the heating and curing of plastic materials. Dielectric heating has its important application where thick sections of plywood, thermo-plastic or thermo-setting materials are involved. The development of thermo-setting bonding materials now permit fabrication of thick sections of plywood in the matter of three to five minutes. Hours were required with steam or other form of heat. The same is true in the heating and curing of plastics. In addition to speed, the electronic method does a more thorough and uniform job. High frequency heating is bound to have an important position in the future in both the plastic and plywood industries.

Another important phase of high frequency induction heating is used in the heating of metals. With this method, faster and more uniform heat treating, annealing, brazing, welding, soldering and tempering have been made possible. In some processes, time has been reduced from two minutes to five seconds. It is possible, by proper choice of frequency and equipment, to case-harden desired surfaces of mechanical parts, such as gears and shafts, and leave the base metal tough and malleable.

The conservation of tin in making tin plate was made possible by the application of induction heating. Tin plate is produced at speeds approaching 1000 fpm. Here high frequency power in a single plant equals the total power of all our conventional broadcasting stations, and the total installations will soon be over 2½ times this figure. It is only a year ago that the early experiments were made on tin plate.

To date, induction heating has been limited primarily

The mass spectrograph, an ionic centrifuge, will analyze very small amounts of gas, or a small bit of solid substance providing it can be vaporized.

▲

Electronic speed regulators, of extreme sensitivity, will automatically hold motor speed constant at any preset value.

to those particular applications important to our war program. After the war is over and the limiting restrictions of supply have been removed, hundreds of new high-frequency heating applications important to the steel, aluminum, tool and general manufacturing industries will be found for electronics.

In the field of communication considerable prophecy has already been made by many leading authorities on frequency modulation, television and broadcasting. Important developments in the past year or so will lead to vast expansion in the number of frequency modulation and television sets. Even in our present broadcasting field the trend of ever increasing power leads us to predict the building of "super-power" broadcasting stations of 750,000 to 1,000,000 watts output.

Carrier current transmission, a less known phase of communication has found increasingly wide application in the past few years. Its use in connection with protective relaying has permitted the capacity of our present power lines to be increased over 50 per cent, with a comparable saving in vital copper and other critical materials. Telemetering, or the remote indication of circuit and plant loading to a central dispatcher in the power distribution system, is another application of carrier current developments. This application facilitates the economic operation of power generating systems. As the power needs of the country grow, this industry will find some of the war time developments in electronics ready to assist in their problems.

In the field of electronic devices for making measurements, a number of developments have been made in the past few years. These developments include dynetric balancing, the electron mass spectrometer, cathode ray, stroboglow, micrometers and many others. Dynetric balancing is highly important today as it measures and locates the position of off-balance components of all types of rotating parts from the tiny aircraft instrument gyros weighing less than ¼ lb to the massive marine gears weighing over 80 tons. In the conventional sizes

These electric air cleaning units remove dust particles as small as 1/250,000 of an inch, protecting motors and other equipment from dirt damage.

Thyratron tubes actuate plug-in telephone type relays in controlling the various steps of some welding processes.

rotors weighing from ½ pound to 100 pounds are often balanced in less than 15 seconds. Former methods required more than one hour. Off-balance components producing vibrations of as low as .0003 in. can be accurately measured electronically, and the position for a balancing weight located within two degrees. This development will be of increasing importance in years to come in helping to build longer life machines with quieter and more dependable operation.

The electron mass spectrometer is a device for the rapid analysis of chemical compounds. At the present moment its most useful application appears in the petroleum and synthetic industries where hydrocarbons and other compounds associated in the production of synthetic rubber and motor fuels require close control. At the present time samples equivalent to 5 cc at atmospheric pressure are qualitatively and quantitatively analyzed with an error in accuracy of less than one per cent. More important is that these analyses are often completed in less than 15 minutes where former methods often took at least a day. The mass spectrometer will be adaptable to many other industries in the future as a means of close control in critical processes. It is even possible that the principles of the mass spectrometer may be extended to the actual production of rare elements.

A few other electronic measuring devices are cathode ray oscilloscopes, stroboglow, speed indicators and micrometers.

In the field of control apparatus the writer's company has been active for many years producing electronic lighting controls, photo-electric devices, smoke recorders, resistance welding controls and motor speed controls. In resistance welding we are at present producing many welding timer units for use in plants welding vital plane parts. As new techniques in welding procedures are established, welding control and sequence timers will play an increasingly important part for these operations.

A rather recent development has been the electronic device which permits the operation of d-c motors from

an a-c power source, with a wide range of speed control, good speed regulation and current limiting acceleration. The speed is controlled with precision from a remote pushbutton station that permits the operator to maintain instant control at all times. At present, it is built in sizes up to 15 hp, with larger ratings probably soon to come. In machine shops and the machine tool industry this means increased production and superior products. Other devices, such as register regulators, voltage regulators and speed regulators, will become common practice in the printing, steel and paper mill industries.

Many types of electronic equipment have been developed for use in the inspection and sorting of products in a diversified group of industries. Industrial x-ray, for instance, is at present applied for the inspection of armor plate, welds, airplane parts and other equipment, spotting certain defects which might otherwise escape notice. In peace time the advantages of this type of inspection may result in safer, lighter automobiles, trucks and planes, as unnecessary safety factors for unseen defects can be avoided.

Photo-electric devices in applications such as pin hole detectors permit the rapid inspection and automatic sorting of prime and defective sheets. Defects which often escape visual inspection are spotted faster than the combined work of a dozen employees. Simple operations such as high speed counting and the control of conveyor lines are applications which are in operation today, but which undoubtedly will be extended to many other industries in the near future.

The precipitation of dirt and dust particles, fumes and smoke has had an important place in a number of industries, such as film processing laboratories, precision instrument factories and arsenal plants. In the machine shops electric air cleaners have removed as much as four gallons of oil a day from the air surrounding a high speed lathe, oil which otherwise would settle on the lights, walls and equipment, as well as in the lungs of the workmen. It is quite probable that units for the home will soon be available to remove irritating pollens as well as dust and germs from the air which we breathe. Even the smoke from combustion gases may be removed from our chimneys to make our homes and communities cleaner places in which to live.

Light radiation is sometimes questioned as to its position in the electronic field. Fluorescent lights, producing more than twice the number of lumens per watt of our filament incandescent lamps, are being used in increasing quantities in factories and homes. A slight variation of the same principles of operation may be more important in our daily life than the fluorescent light. This device is a lamp acting as a source of ultraviolet radiation, with the property of destroying many types of bacteria. The demand has been so great that production has been unable to keep pace. Its applications are so universal that it is not improbable that our homes, refrigerators, laboratories, meat storage and curing vaults, food processing and handling industries, public meeting places and so on will be completely equipped in the future.

Radar, the great development of this war, will have many applications to the transportation industry when the demand for military equipment has passed. Our planes will fly in greater safety; our liners dock at their berths without delay even though fog shrouds the course to be covered. The location of every mountain, plane, boat or rock within the danger area will be instantly known to the controlling personnel. It may be used on railroads, reducing the hazard of collisions.

It is not possible to anticipate all the future developments made possible by electronics. The possibilities are beyond imagination. However, many applications exist where electronics can do the work better than other types of equipment, do some things not possible in any other way. But electronics cannot do everything. Many possible applications are not economical or practical. With electronics now on the tip of every tongue it is essential that every experienced electronics engineer weigh carefully every request, every possible application, to avoid misapplications which may lead to delay in acceptance on jobs it can do well.

The vast production capacity developed to meet present war time requirements will place electronics in the position to serve the needs of the post war world, but our development effort and production facilities must be used wisely. It is important that we keep our feet on the ground, lest the electronic field again be smothered by adverse publicity caused by misapplication.

Starie PAPER

(*Continued from page 75*)

control, while Figure 4 shows a conventional control for such a mill. The use of the special exciter is more than offset by the elimination of the motor-operated generator field rheostat.

5. *Better coordination and reduced maintenance* — The foregoing advantages result in closer relationship between motors and rolling requirements, that is, better coordination, and in increased reliability and lower maintenance time and expense, because of the reduction in number and size of control devices needed.

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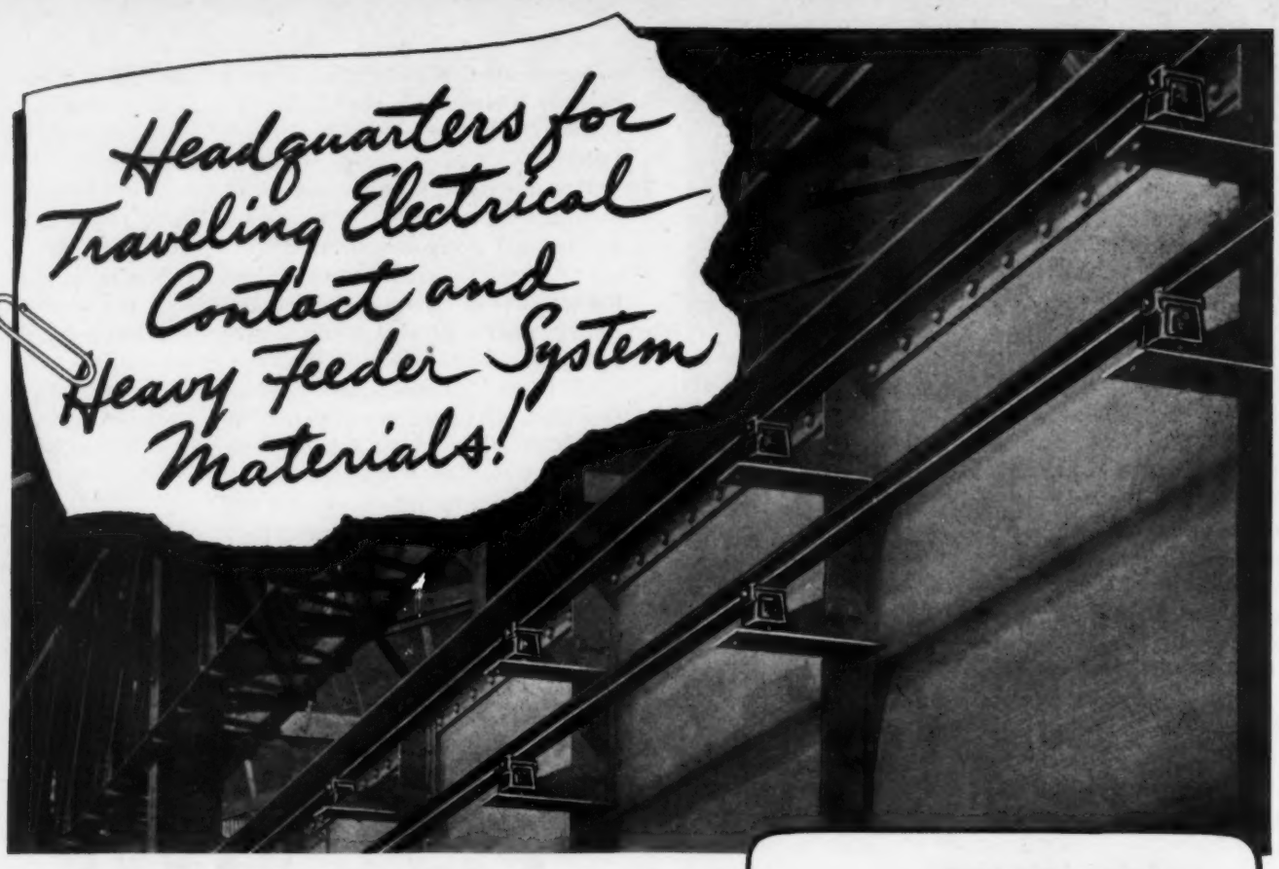

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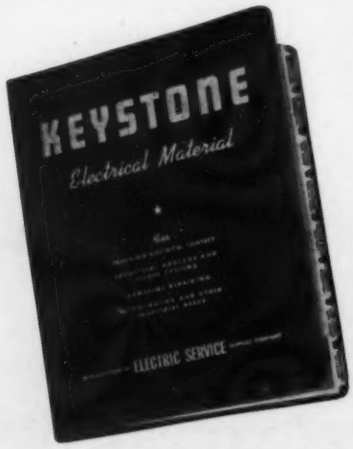

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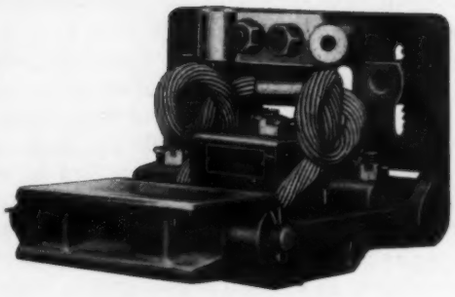
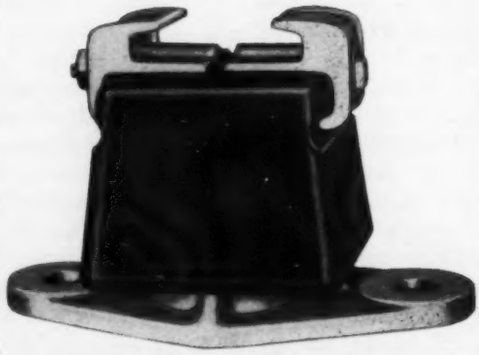


Typical Keystone Reversible Contact Rail Shoe



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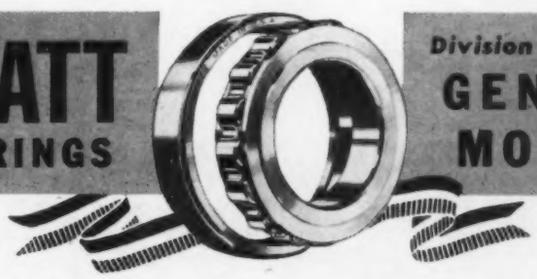

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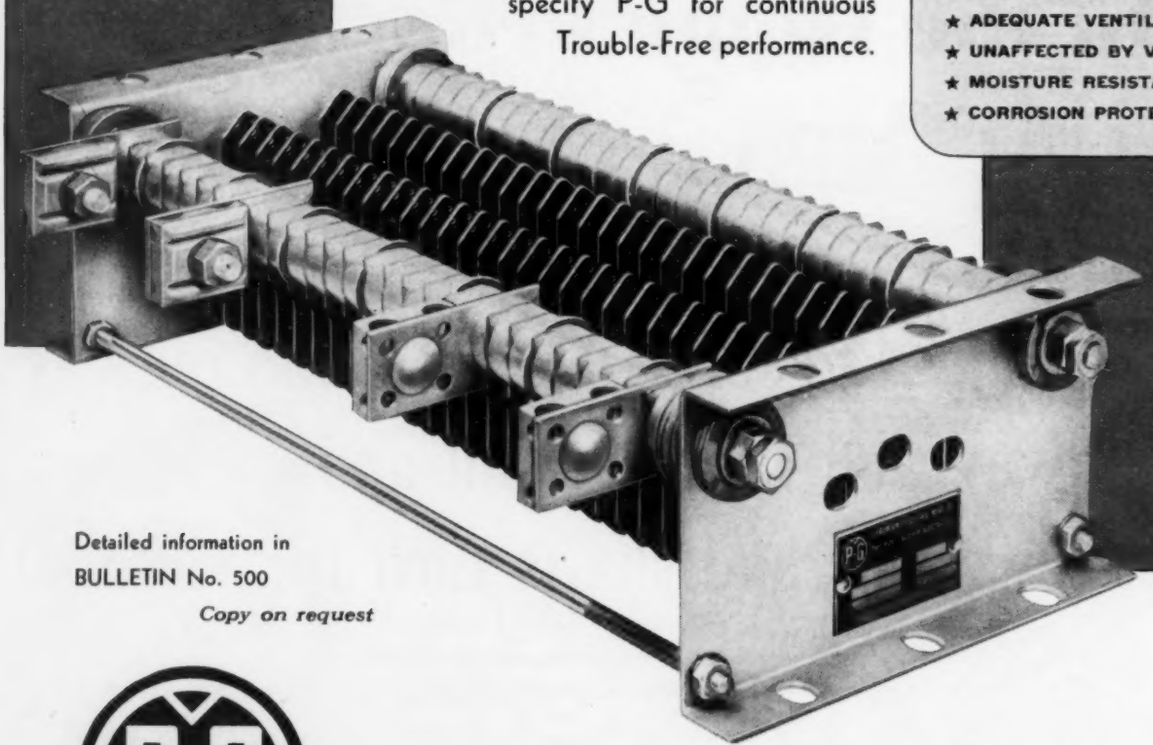

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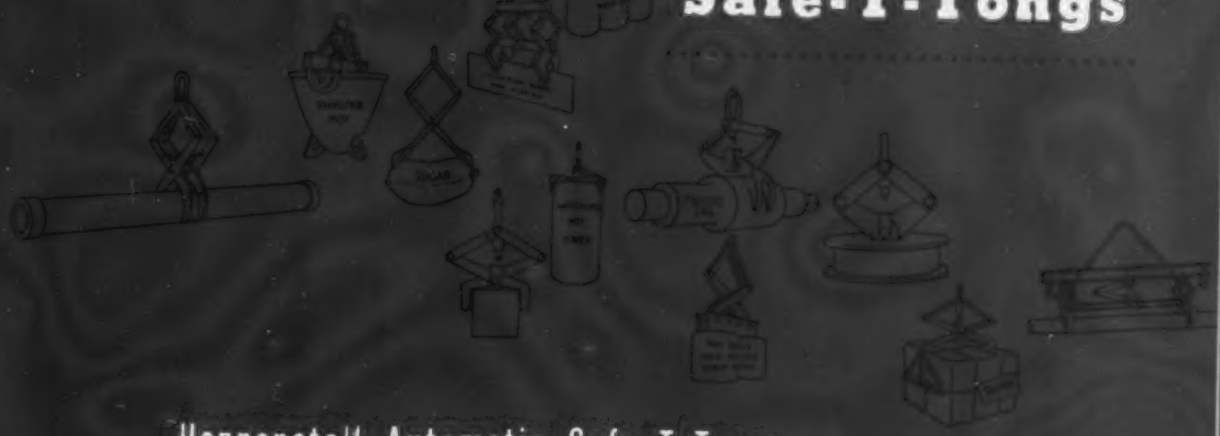

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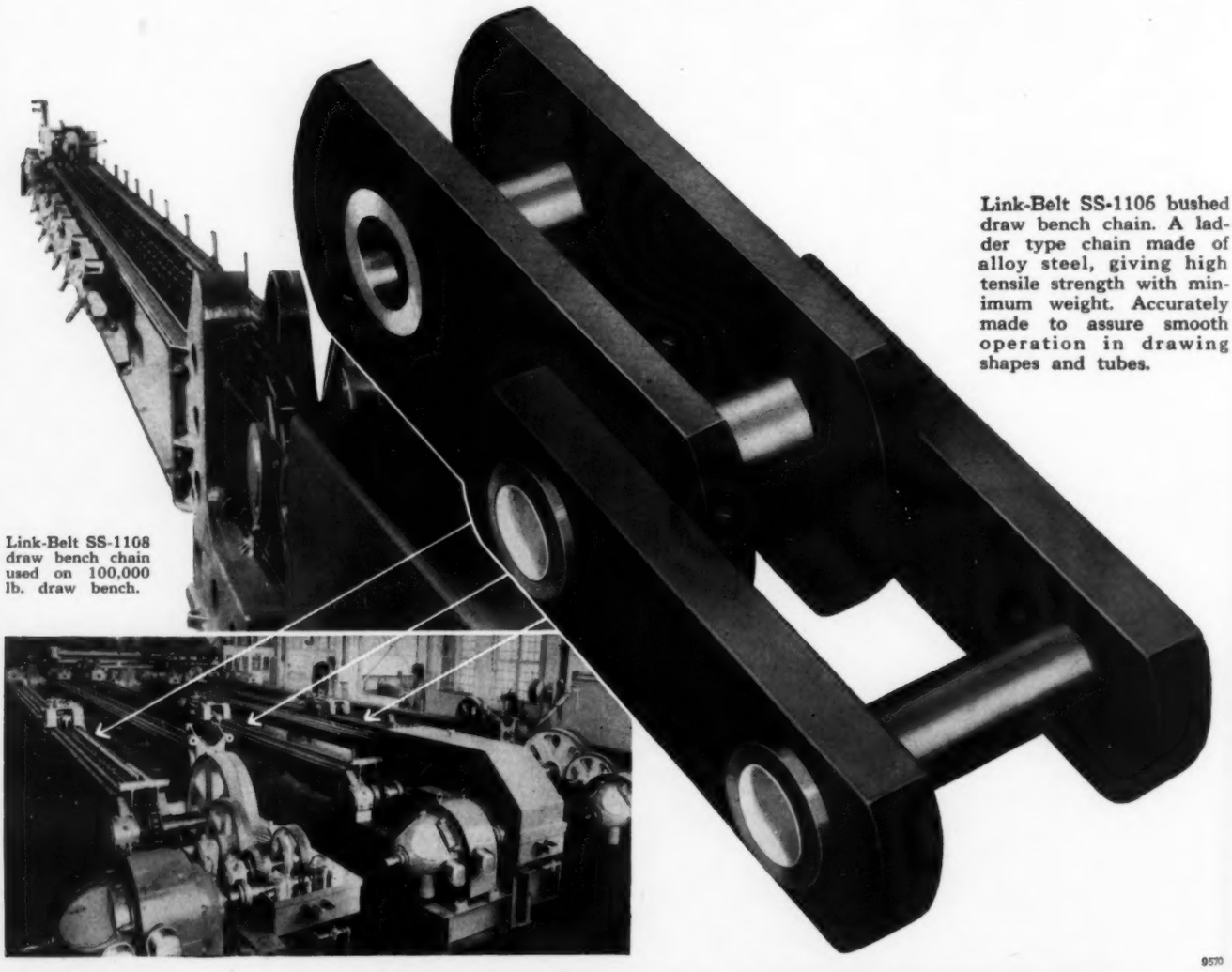

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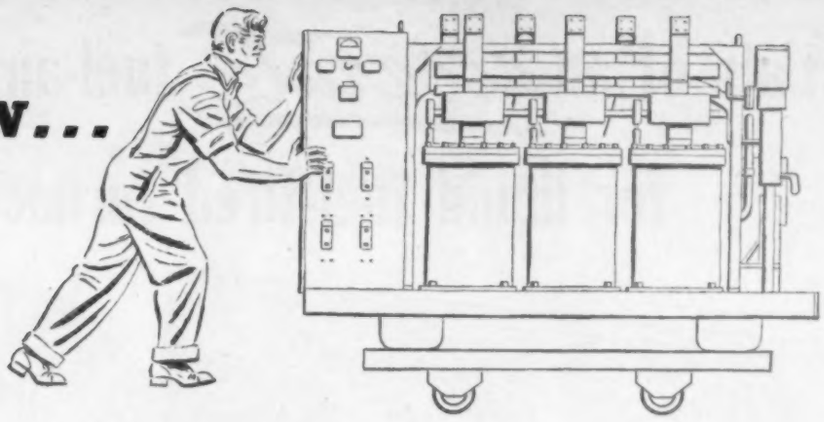
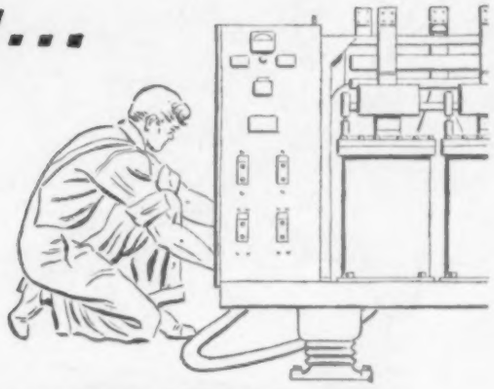


CONNECT IT...



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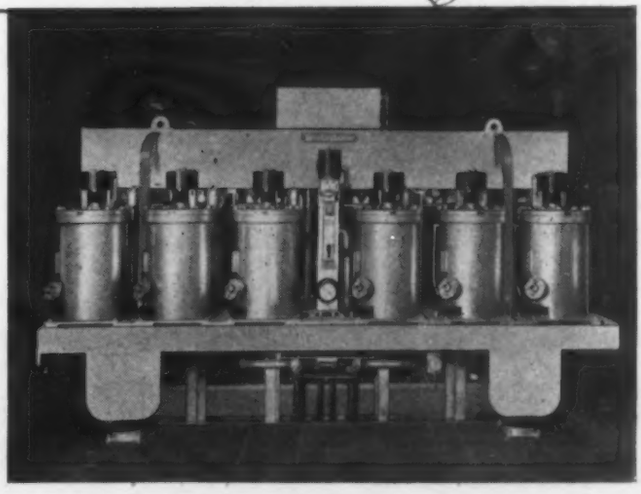
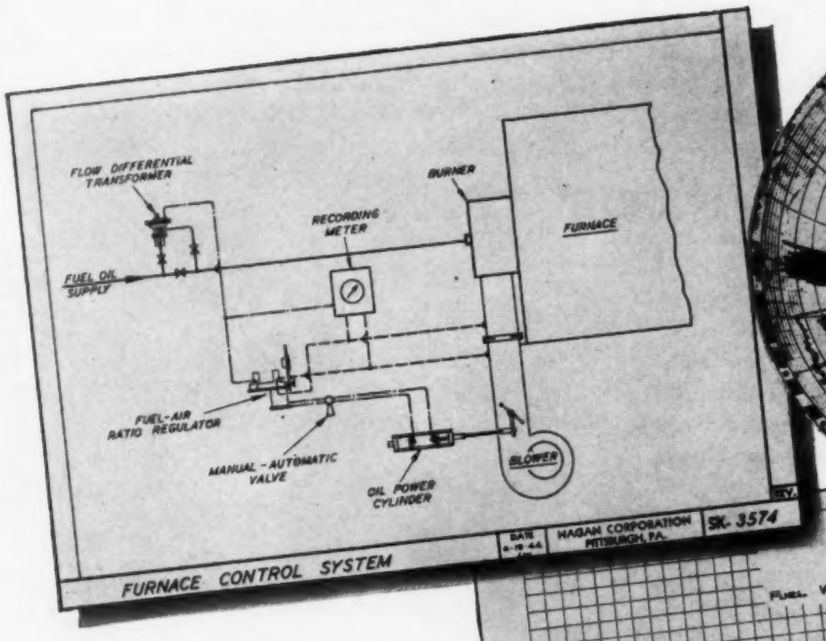


Essentials of an *accurate* fuel-air ratio control for liquid fuel-fired furnaces



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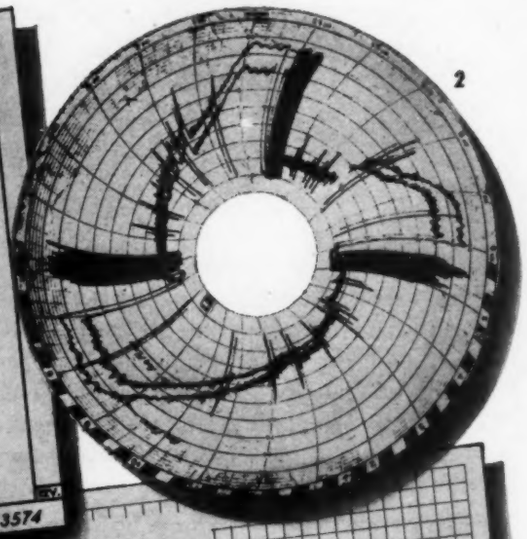

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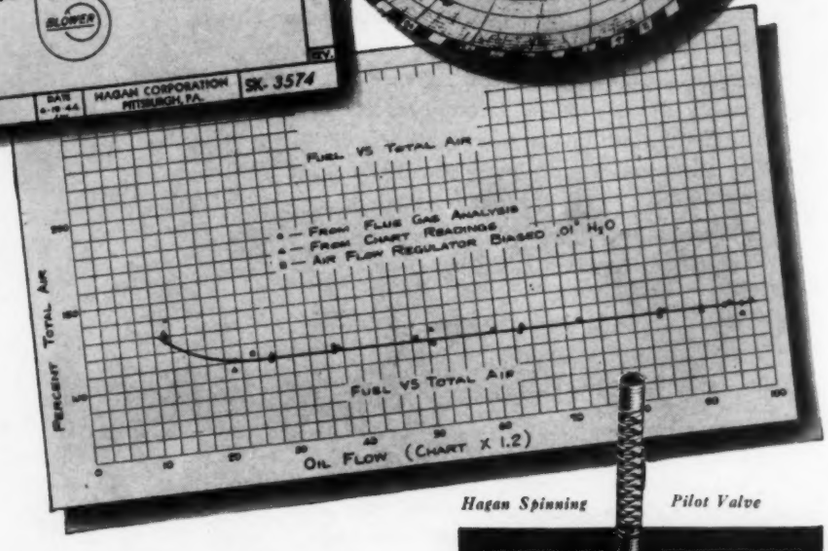

FUEL VS TOTAL AIR
a — FROM FLUE GAS ANALYSIS
a — FROM CHART READINGS
b — AIR FLOW REGULATOR BIASED .01" H_2O
PERCENT TOTAL AIR
FUEL VS TOTAL AIR
OIL FLOW (CHART X 1.2)

3.

1. Typical Control diagram showing Hagan fuel-air ratio control applied to an oil-fired furnace.

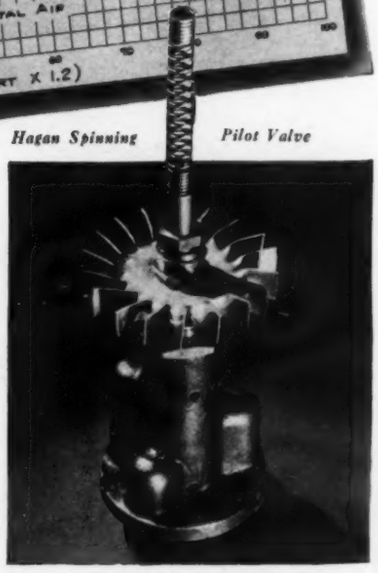
2. Typical chart record taken from an oil-fired soaking pit equipped with the Hagan fuel-air ratio control shown in figure 1.

3. Percent theoretical air plotted against oil-flow rate. Regulator adjusted to provide slightly increased excess air at low firing rates to compensate for reduced turbulance at burner outlet at these low rates.

THE main difficulty in the regulation of fuel-air ratio in a liquid-fired furnace centers about the oil or tar flow-rate measuring device. For best results, the measuring device must possess an inherently high degree of accuracy—and it must maintain this accuracy indefinitely. The device should be independent of changes in viscosity caused by variations in fuel temperature and composition and it should be unaffected by carbon and grit particles in the oil.

In the Hagan oil differential transformer, all the oil to be measured passes through the unit thereby eliminating the need for feeler lines. A floating orifice of proper design reduces viscosity effects to a minimum. Absence of closely fitting moving surfaces assures dependable, accurate operation under dirt and grit conditions that make other types of liquid metering devices inoperative.

Hagan Spinning Pilot Valve



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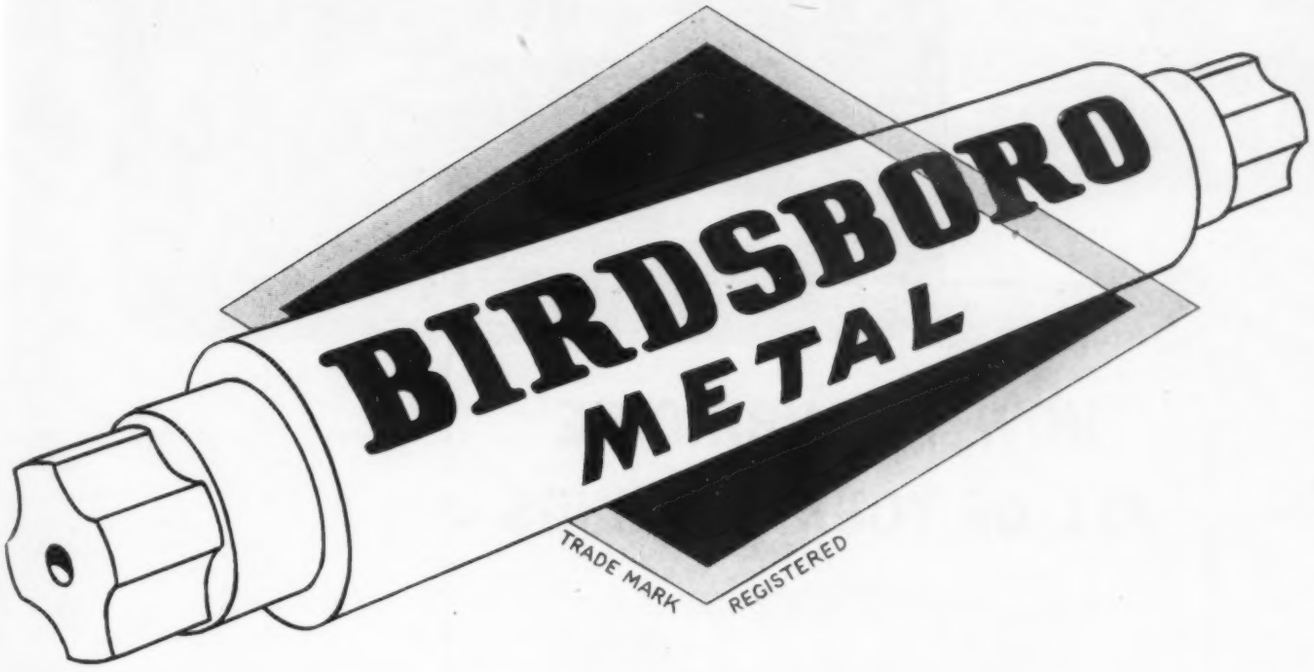

The new Birdsboro Metal roll is designed specially for rolling special steels. If you are experiencing difficulty in rolling aircraft quality steel, alloy steel bars, corrosive steels or non-ferrous metals, try Birdsboro Metal rolls and get higher tonnages, less reduction per dressing, added toughness and roll strength. Call Birdsboro today!

BUY WAR BONDS

BIRDSBORO STEEL FOUNDRY & MACHINE CO · BIRDSBORO, PA.

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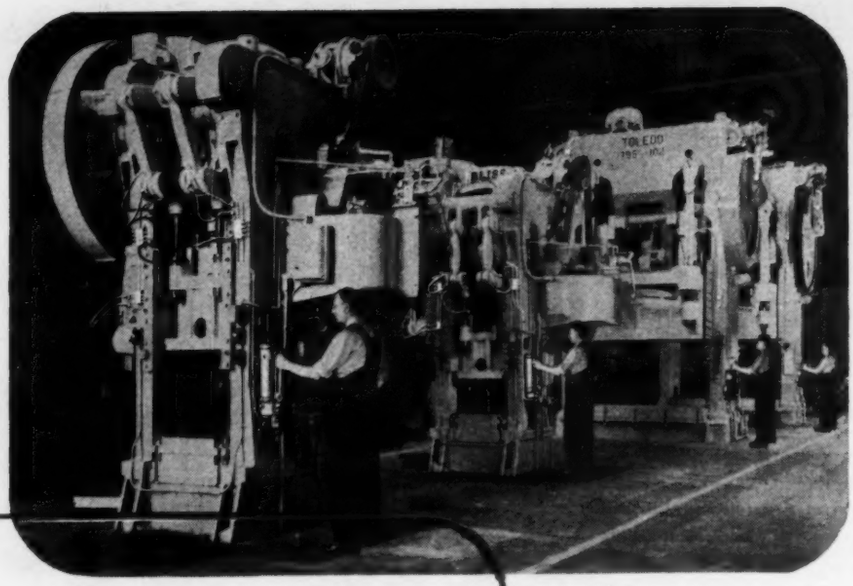
ROLLS



HOW TO LUBRICATE ALL OF YOUR BEARINGS *at once*

Even the "Highest-up" and "Hardest-to-reach" Bearings

With Farval you can give a contented thought to the "aloft" bearings—on your Presses, Cranes and other off-the-floor equipment. No harm if your oilers cannot climb up to them—no harm if they never *see* them. Because your Farval Centralized Systems will "see" even the farthest bearings—will reach them with a measured amount of lubricant, just as frequently as needed.

With Farval your oiler operates a Central Pumping Unit from *one* point, sending a positive charge of oil or grease under pressure to *every* point on the equipment. No bearing receives too much or too little—never a bearing is missed.

With Farval you can lubricate a whole machine in 60 seconds. *Without* Farval you can lose hours in replacing bearings wrecked by the lack of proper lubrication.

The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company
Industrial Worm Gearing
In Canada: PEACOCK BROTHERS LIMITED

NEWS SUPPLEMENT July 1944

Equipment
Personnel
Literature

Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SUCCESSFUL OPERATION REPORTED FOR ORE CAR THAWING PLANT AT EDGAR THOMSON WORKS

▲ Foreshadowing a process likely to be widely adopted by steel makers, an ore car thawing plant constructed by Rust Furnace Company, Pittsburgh, Pennsylvania, for Carnegie-Illinois Steel Corporation, a U. S. Steel subsidiary, successfully completed its test period during the latter part of the past winter, according to a report made public recently.

Purpose of the plant, according to Rust engineers, is to overcome the winter-time condition in which ore from the Lakes becomes soaked with moisture and freezes in the cars so that it will not run out when dumped.

This condition has been met by crude and inefficient methods in the past, which have included holding gas jets against the cars, building wood fires under them, and placing them in sheds under steam for hours — all wasteful of time and labor, and incidentally not contributing to the life of the cars.

Accordingly, an automatically operated plant for the specific purpose of surface thawing ore cars, so as to permit the ore to fall free of the car when unloaded by a dumper, was planned by Carnegie-Illinois.

Erected and put in operation in the latter part of the winter, this plant consists of a building with a capacity of two 90-ton ore cars on a track which runs through it. An additional track is provided for an electrically operated pusher locomotive. Housed on a second floor are combustion units for producing hot gas for recirculation and application against the cars.

The arrangement includes thaw chamber, where the cars stand, two double chamber furnaces with rated capacity of 10,000,000 Btu per hour each, two fuel oil burners, combustion air fan, fuel supply line, steam supply line for fuel atomizing, and motor-driven air recirculating fan, together with the necessary ducts, passages and controls.

The thawing operation consists of circulating air and gases from the combustion chamber through a closed air circuit, comprising the thaw chamber, furnace, fan and interconnecting ducts, the air being alternately heated and cooled in its passage.

In operation, two loaded cars are positioned in the thaw chamber, either being drawn in by locomotive if first in line, or moved by the pusher locomotive.

After the pusher locomotive withdraws, its operator, who has complete charge of the thaw chamber electric control, automatically sets derailing devices on the rails, and also a red light signal, blocking traffiic in and out of the chamber. The impulse from the same control sets up a circuit to close the doors.

The closing of the doors automatically puts in operation the furnaces and air recirculating fans. An adjustable cycle timer regulates the thawing cycle in two periods gauged by the operator according to the hardness of freeze. The periods are approximately: (1) ten minutes flash heating in excess of 500 F, (2) cutback to between

Ore car thawing furnace constructed for Carnegie-Illinois Steel Corporation, a United States Steel subsidiary, by Rust Furnace Company, Pittsburgh, Pennsylvania. Cars are shown leaving the furnace where ore frozen in the trip from the lakes is thawed so cars can be dumped. The furnace provides a modern solution to what has been a time-wasting problem of winter ore handling in many steel mills.

200 F and 250 F for five to ten minutes of base heating or soaking. At the end of this cycle, the operator opens the doors, this electrically-controlled action causing the fuel shut-off valve to close and stop the air recirculating fan. A pilot flame is left burning to initiate the next combustion cycle.

The two thawed cars are then drawn out by the dinkey and spotted on the car dumper platen. Here their surface-thawed ore is dumped into electrically drawn transfer cars which take it away to stockpile or furnace.

The experience with this plant, although rather mild weather did not make the normally expected demands on it, was sufficient to show the plant provides an efficient solution for the problem of frozen ore cars, with savings in time and labor.

MORE PRODUCTION UNITS FOR SHELL PROGRAM

▲ A program which was put into effect during the defense period prior to Pearl Harbor by the officers of the Pittsburgh Ordnance District will contribute materially toward success in the production of large artillery shell for the Army. It was in 1940, at the request of the Ordnance District, that F. C. Biggert, Jr., chairman of the board of United Engineering and Foundry Company, started development of an hydraulic billet piercing press, which has shown unprecedented speed in production and economies in manpower.

Three have been in operation for making 6 in. shells—two at National Tube Company in McKeesport, and one at Tennessee Coal, Iron and Railroad Company in Alabama. In addition, five more of the same size (400 tons) are on order, two for Bethlehem Steel Corporation, one for Tennessee Coal, Iron and Railroad Company, one for Oldsmobile Division of General Motors and one for United Engineering.

United Engineering also is building a similar press of 800 ton size for 8 in. shells for itself and has another on order for Kentucky Shell Company, Newport, Kentucky. Further, it is designing one of 1200 tons to produce 240 mm shells for Bethlehem Steel.

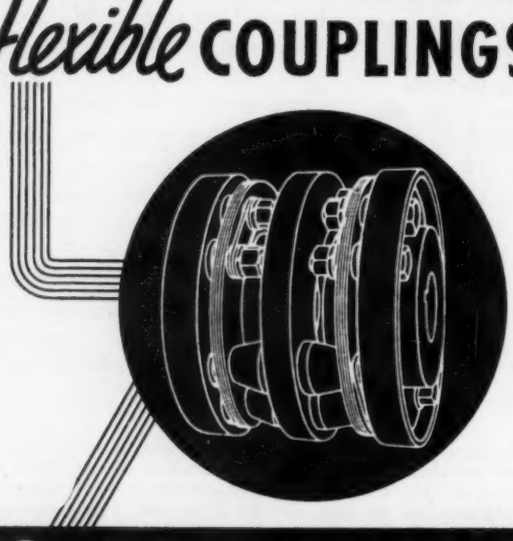
Thus, not only is the company producing presses for others, but it also has an Army Ordnance contract to forge and machine six-inch and eight-inch shells at New Castle, Pennsylvania. This contract, including installation of equipment and cost of shell, will aggregate a total sum of between $25,000,000 and $30,000,000.

The United press consists of a machine which has four punches on a rotating turret. The four stations are loading, piercing, unloading and cooling. This arrangement is economical of punches and with handling equipment to permit high speed operation has resulted in an average production of 200 six-inch shell per hour, or roughly twice as many as have been produced on any other type of shell piercing press.

The billet is centered in a holder at the loading station and the piercing is accomplished by lowering the die over the billet and thus forcing it over the stationary punch. Following the piercing, the shells are elongated over a mandrel in an hydraulic roller draw bench operation. They are then ready for machining.

In its own installations of presses and other equipment at the New Castle Plant, United Engineering is utilizing a highly conveyorized plan with automatic machines to reduce requirements of manpower.

THOMAS
Flexible COUPLINGS



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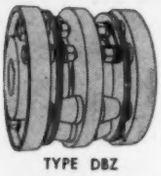

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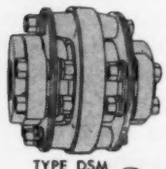

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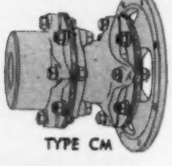

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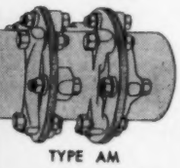

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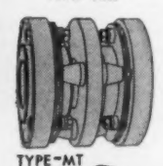
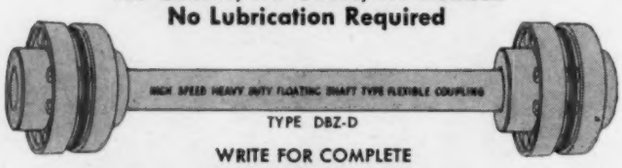


TYPE SS

Eliminate BACKLASH, FRICTION, WEAR AND CROSS-PULL
the four destructive evils of other types and makes of couplings that prevent a permanent care-free installation.

The Thomas All-Metal Coupling has:
No Chains, No Gears, No Rubber.
No Lubrication Required



TYPE DBZ-D

WRITE FOR COMPLETE ENGINEERING CATALOG

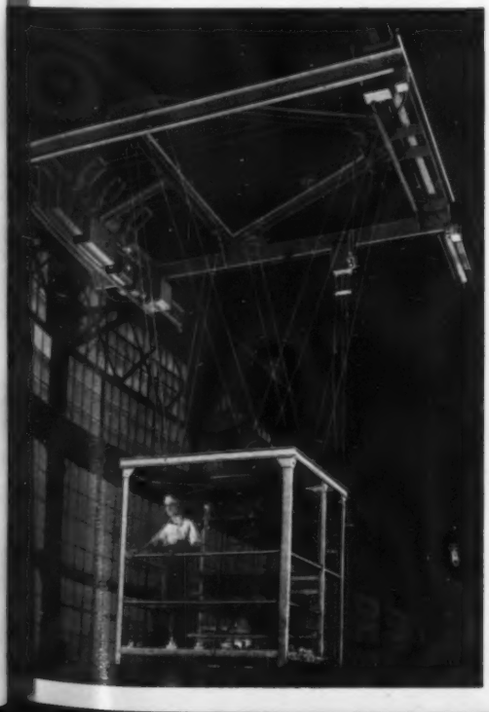
THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

TRAVELING PLATFORM AIDS SHIP PAINTING

▲ The Cleveland Tramrail Division of The Cleveland Crane and Engineering Company, Wickliffe, Ohio, have developed a new stabilized traveling platform that can be raised or lowered without swing as firmly as though held by vertical guides. It can be traveled to any point longitudinally or laterally in an area covered by the crane on which it is operated.

The stabilized platform was designed for spray painting large air cargo ships and to aid with some of the assembly operations. The floor area of the platform is divided into two sections: approximately one-third at the rear is for drums of paint and other equipment carried; the large space in front is for the painter's use.

Three master drum controllers are mounted on the railing at the rear of the painter's area, for operation of the hoist, bridge and trolley motions. Speeds may be varied with these controllers. Three sets of foot-operated controllers are also provided on the floor along the three outer sides of the painter's area. These enable the painter to move the platform to any location desired by use of controllers on the side of the platform that he is working from. They provide single slow speed motions convenient for spray painting. Thus, the painter's hands are free to hold the spray nozzle and apply the paint carefully and without hindrance while operating the platform.



Besides the usual upper limit switch for preventing the platform being hoisted beyond the upper limit, an important feature provided to aid safety when lowering, is the slack cable release. Through means of this feature, the platform is stopped immediately when lowering if any part of it comes in contact with any object sufficiently to cause slackening in any of the hoisting ropes.

The unit illustrated is of the all-welded steel construction. It will carry a load of 5 tons and has a hoisting speed of 18 fpm. This type of stabilized platform is suitable for operation through a vertical height up to 30 ft and may be furnished for operation at any hoisting speed from creeping to 50 fpm or more.

LARGE TRANSFORMER FOR POWER INTERCHANGE

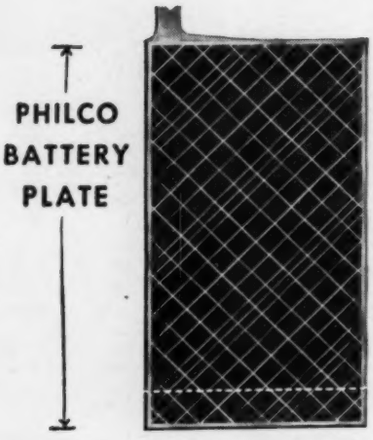
A 37,500-kva, 3-phase, 60-cycle power transformer, recently shipped from General Electric's Pittsfield Works to The Kansas Power and Light Company, will form a nucleus for power interchange, bringing electric power in from several private utilities. This will make available sufficient power for two vital ordnance plants which might otherwise face curtailed activity because of a possible power shortage in the Mid-west.

Without any means of cooling other than the natural circulation of air, this unit will supply a load of 37,000 kva, and is provided with fans to permit this to be increased to 62,500 kva with forced air cooling. The transformer is designed to step the voltage down from 161,000 volts to 110,000 volts as an autotransformer, while power is also fed in at 13,800 volts from a generator plant at the substation.

TOOL TIPS FOR USE IN FABRICATING TOOLS

▲ Tool tips cast from Haynes Stellite cobalt-chromium-tungsten alloy are available for shops desiring to fabricate their own metal-cutting tools. They are made by Haynes Stellite Company, a unit of Union Carbide and Carbon Corporation, Kokomo, Indiana. Metal-cutting tools made by brazing these tips to steel shanks are recommended for jobs employing tools of large cross sections or tools that are bent or offset, or in tool holders which make the use of solid tools impractical. Tipped tools also offer an additional advantage on operations that necessitate considerable overhang of the tool — the Haynes Stellite tool tip provides the red-hard,

WHY PHILCO BATTERIES HANDLE *10% MORE TONS— MORE LOADS PER DAY*



There's no mystery about why modern extra capacity Philco Batteries step-up the work capacity of your industrial trucks by 10% or more. There is a purely mechanical reason. Philco plates are larger. Their physical dimensions are greater. And a Philco is so constructed that it gives this 10% more power capacity in the *same* compartment space. That's why a Philco Battery, type for type, provides an extra reserve of power—why the voltage stays up longer—why the battery lasts longer. Ask for latest Philco Industrial Truck Battery catalog. PHILCO CORPORATION, *Storage Battery Division, Trenton 7, New Jersey.*

Specify

PHILCO INDUSTRIAL TRUCK BATTERIES

Backed by 50 years of experience in industrial storage battery development

abrasion-resistant cutting edge and the steel shank to which the tip is brazed provides the strength and toughness necessary to withstand the strain resulting from such operations.

Ten standard shapes of tool tips are available, in each of ten standard sizes, cast from either 98M2 or Star J-Metal alloy. Each has the joint faces (bottom and one end) bronze-tinned for brazing. Standard tips can also be furnished without the bronze coating, if desired. Stock is allowed on standard tips for finish to nominal size.

Complete information on shapes, sizes, and prices of these tool tips is available from Haynes Stellite Company, Kokomo, Indiana.

SAFETY RULES FOR POWER TRUCK OPERATORS

▲ As a contribution to the present drive for reduction of accidents in industrial plants, The Elwell-Parker Electric Company, Cleveland, Ohio, has formulated a set of safety rules for operators of power industrial trucks. These rules are intended to supplement the basic instruction of the operator and to interpret the general precaution to "Drive Carefully." It is pointed out that in most cases it would be advisable to modify them by specific reference to local conditions, such as observance of one-way routes, hints for checking loads before pick-up, etc.

Rules for safe operation of power trucks:

1 — *Move control levers firmly from one speed to another and without hesitation.* This is to prevent arcing, which pits the contact surfaces of the switch. If you allow these contacts to become damaged you may fail to get the expected response from your control lever at a time when you want it very much.

2 — *Keep your load as low as possible when moving.* There is no danger of tipping a load carried at a low level. Keep it low enough so that you can see over it.

3 — *Keep your truck behind the load.* If you should get off suddenly, or fall off, then the load will be moving away from you and it can do you no harm. When going up steep inclines it is sometimes better to reverse this position and have the truck pull the load.

4 — *Avoid making quick or jerky stops.* The momentum of the load may play tricks on you. Be especially careful about stops when you have a load elevated for tiering or stacking.

5 — *If your truck has a tilting device — use it.* By tilting the upright toward you the weight of the load is brought back slightly and the balance is improved. This slight tilt of 10 to 15 degrees will avoid spilling the load when rounding corners.

6 — *Go easy when approaching danger points.* These are: elevator gates, pits, bridges, inclines, tunnels and tracks. Get the habit of crossing tracks diagonally instead of at right angles.

7 — *Take a good look at your load before you pick it up.* If you have to move a doubtful load, slow down.

8 — *Be sure to pick up every load squarely.* Then there is no danger of the load shifting, due to offside loading, while you are in motion. When small boxes in pallet or skid lots are raised above the uprights, be sure that those on the back corners have not shifted to fall on you. Insist on wide load back rests.

SCHLOEMANN "Motor-Rollers"

REDUCE OPERATING AND MAINTENANCE COSTS

Double Tapered "Motor-Rollers" for Aluminum Plate Mill Ready for Mounting on Mill Table

★ Operating expenses and maintenance on shear, scale, or mill tables subject to unusual or interrupted runs can be lowered with the installation of Schloemann "Motor-Rollers."

Flexibility of movement is possible since the squirrel cage motor is housed in a free turning shell with anti-friction bearings and a minimum number of rotating parts. When the electric current is disconnected each "Motor-Roller" acts as an idler Roller.

Schloemann experience and skill are also utilized in the engineering of extrusion presses, air hydraulic accumulators, accumulator controls, and complete hydraulic systems.

SCHLOEMANN
ENGINEERING CORPORATION
1102 EMPIRE BUILDING . . . . . PITTSBURGH 22, PA.
HYDRAULIC PRESSES • ROLLING MILL MACHINERY

9 — *Report rubbish on floors to your foreman.* You and your truck are safer on clean runways.

10 — *Don't cut corners.* You are in danger of having to stop quickly — lose the load — hurt someone or damage the goods.

11 — *Keep your truck clean.* Dirt and rubbish make your footing uncertain and may cause trouble if obstructions lodge somewhere in the mechanism.

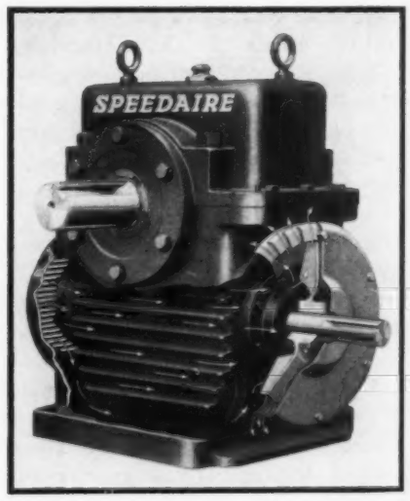
12 — *Don't carry passengers.* You need all the room you have for perfect control of your truck.

13 — *Don't allow others to operate your truck.* They may injure someone, or damage the truck or tires. It takes time to get spare parts these days.

14 — *Report need for repairs immediately.* Repairs take the least time when they are made promptly.

COOLING INCREASES REDUCTION GEAR CAPACITY

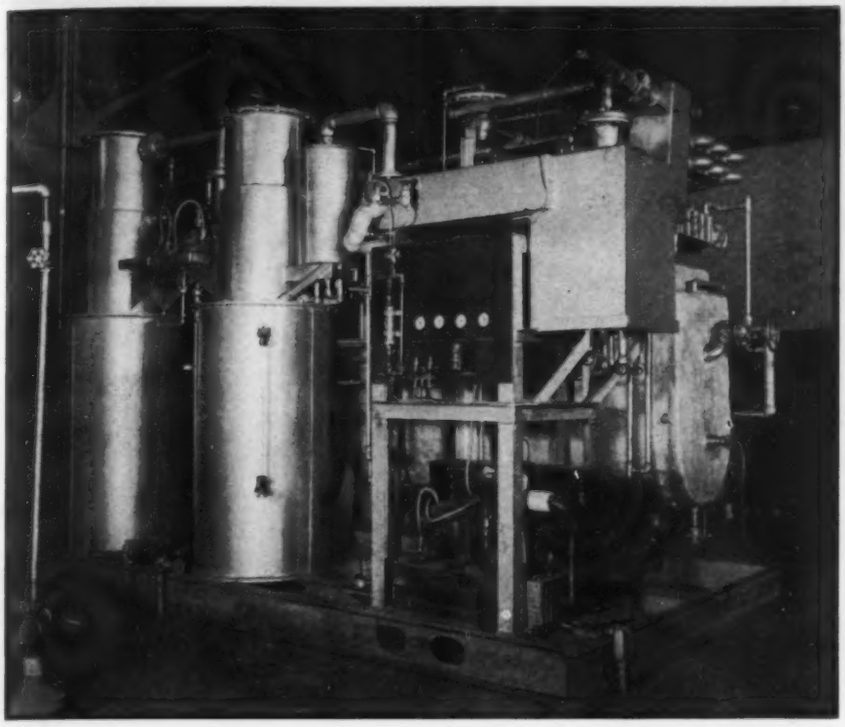
▲ Newly announced by Cleveland Worm and Gear Company, Cleveland, Ohio, is the Speedaire Worm Gear Reduction Unit, incorporating a fan cooling system which permits a pronounced reduction in size of the unit required for a given hp output.



Air under induced draft from a radial fan on the worm shaft enters through the grille at left and is distributed effectively over the warmest surfaces.

The basis of the cooling system is a new type of double wall construction. This provides an air passage completely enveloping the oil reservoir in which the gear operates. The inner housing wall forming the oil reservoir is deeply finned on the air side, resulting in a marked increase in heat-dissipating surface.

PREPARATION UNIT FOR INERT ATMOSPHERE GAS



NX gas atmosphere for heat treating operations is used particularly with molybdenum, vanadium and high alloy steels. This Surface Combustion gas preparation unit is installed in a leading steel mill where it is used in the heat treatment of high alloy for stock. The unit has a capacity of 8000 cu ft per hr. NX gas (inert nitrogen) is used also in the process of atmosphere forging.

An exhaust fan located on the coupling end of the worm shaft draws air at high velocity through the space between the housing walls from a grill at the opposite end of the unit. This fan is designed to operate with either direction of rotation. The effect of the double wall construction is to maintain a uniform flow of cooling air against the fins and housing wall over the whole oil reservoir surface, and thus completely to utilize the full heat transfer efficiency of the system.

The operating temperature is greatly lowered by means of this high velocity air stream enveloping the oil reservoir, giving the Speedaire unit a much greater load-carrying capacity than a standard worm gear unit of equal size, when operated at the usual motor speeds.

In many instances it is possible to obtain an operating capacity with Speedaire units equal to that of standard worm gear units having approximately double the housing dimensions. Under given conditions of installation an advantage may be derived from reduced size or reduced weight. In either case there is a material reduction in the dollar cost per horsepower transmitted.

DEVICE FOR MARKING TUBES AND COUPLINGS

▲ The new Cunningham tube and coupling marker facilitates the stamping of tubes and couplings from 1 in. to 16 in. in lengths. The marker is quickly slipped into position, clamping under both ends of the tube or coupling being marked. The non-slip knurled handle readily locks the marker firmly in position with no further adjustments necessary. The marker is released by merely lifting up on the handle.

The figures are constructed of Cunningham safety steel, the marker affording complete safety with clean, clear marking and high speed operation. The marker is available for various amounts of characters, depending on the size of the marker and of the characters.

Further details are available by writing direct to M. E. Cunningham Company, 105 E. Carson Street, Pittsburgh 19, Pennsylvania.

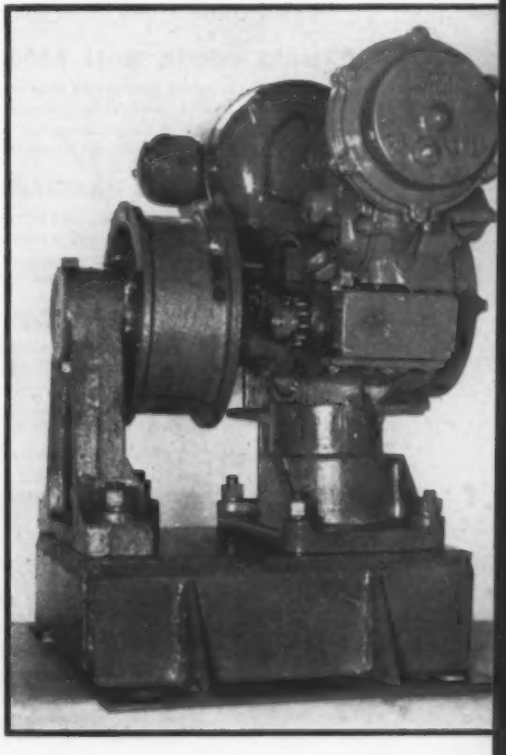
FURNACE DOOR HOIST OPERATES WITHOUT COUNTERWEIGHTS

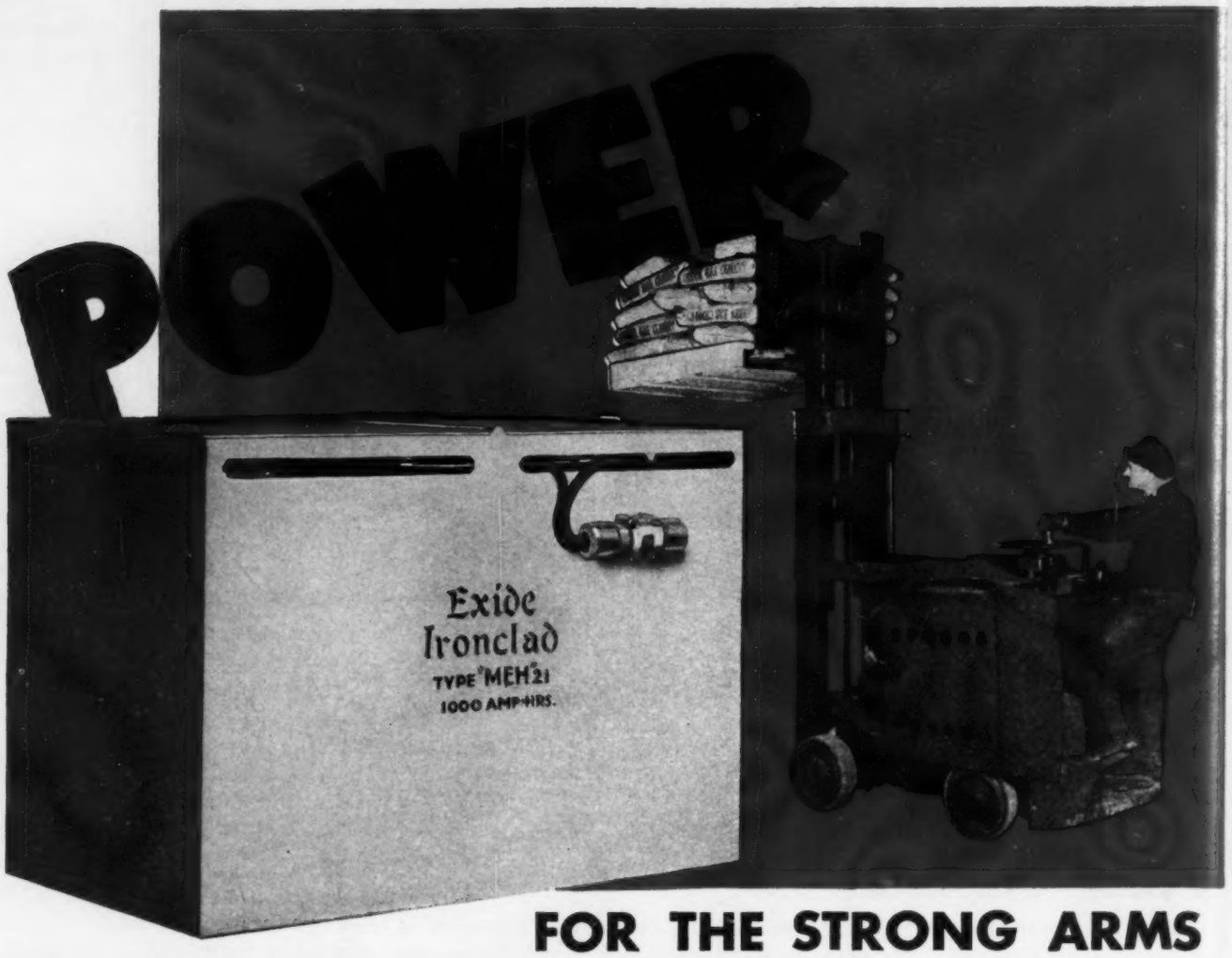
▲ Fred J. Ryan Company, Wyncote, Pennsylvania, have introduced a new model hoist unit which becomes a standard item in their diversified list of industrial furnace and oven door electric hoisting units.

A new hoist which is known as the model RD unit is for floor mounting and, as standard with all Ryan units, operates without counterweights. It is adaptable for use with either chain or wire rope lifting members.

The RD unit, like all other models, is adaptable to either new or old installations. It is claimed that through the use of the standard assembled parts, installation in most cases can be made in one hour.

Some of the outstanding features of the Ryan hoist equipment are low horsepower demand, absolute positive control on both braking and limit of operation plus rugged, fool proof construction.





FOR THE STRONG ARMS OF INDUSTRY . . .

EXIDE-IRONCLAD BATTERIES OFFER THREE VITAL POINTS OF SUPERIORITY

MORE POWER, MORE PRODUCTION:
An Exide-Ironclad delivers its power at uniform voltage to assure constant hauling speeds. There is always a giant surge in reserve when an Exide powers your battery propelled vehicles.

LONG-LIFE SAVES MATERIALS:
Every Exide is built to last, and saves vital materials by squeezing the last ounce of use out of the materials in it. When you buy an Exide, you definitely . . . Buy to Last and Save to Win.

EASY MAINTENANCE, SAVES LABOR:
Exides are kept charged by the simplest method ever devised. With the Exide Charge Control Unit all you do is connect battery to the charging source and turn a knob.

ARMY E NAVY

Exide
IRONCLAD
BATTERIES

For loading, unloading and load-shifting, you just can't beat an electric industrial truck, powered by an Exide-Ironclad Battery. These trucks, designed to handle material with the greatest efficiency, combined with rugged, Exide-Ironclad Batteries, give you a materials handling system that is streamlined to the utmost.

Exide-Ironclads are widely recognized as a source of never-failing power. They provide extra efficiency for an already highly efficient operation. Exides have long been known for their extreme dependability, long-life, and simplicity of maintenance. The steps you take to modernize and streamline with Exide-Ironclads mean economies that are yours for years to come.

Write us for a FREE copy of the bulletin "Unit Loads," prepared by The Industrial Truck Statistical Association. It tells how to cut handling costs up to 50% . . . covers latest developments in materials handling . . . and includes actual case histories.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia 32

Exide Batteries of Canada, Limited, Toronto

How Houghton helps

A WAR-TIRED PLANT

get its

"SECOND WIND"

1 By drafting a SIMPLIFIED LUBRICATION PLAN...

Competent lubricating engineers can check your machines upon request, setting up a flexible system adapted to your plant's needs, and without disturbing production. The objectives of such a plan are (1) proper lubrication of every machine; (2) establishing positive lubrication control; (3) reduction in number of varieties of lubricants required. This plan is presented to plant executives in concise and permanent form, easy to follow.

2 By supplying FORTIFIED LUBRICANTS...

The wise choice of lubricants involves more than following name-plate advice . . . more than a superficial knowledge of petroleum stocks . . . more than buying oils on physical properties alone. Selection of the right oils and greases is a serious responsibility today in war plants whose machines have been pushed to full capacity for many months. On that decision may depend the ultimate useful life of the machine and freedom from down-time. Houghton lubricants are scientifically treated to enable fewer grades to cover more needs and to hold up longer under gruelling war production. These treatments include polymerization, high-film-strength, corrosion-inhibiting, gum solvency and oxidation stability. The Houghton Man can tell you how "Oil with Guts" can fortify the war-tired plant. Ask him, or write E. F. HOUGHTON & CO., Philadelphia 33, Penna.

FIRST AID FOR OVER-WORKED MACHINES: High-film-strength, polymerized Sta-Put Lubricants ★ Dynamo-Turbine-Compressor D. L. Absorbed Oils ★ Fortified-film "High-V.I." Hydraulic Oils ★ Reversible, stable "Absorbed Oils" for Ball and Roller Bearings ★ E. P. Spindle Oils, Gear Oils, and a host of other fortified lubricants built for war plant duty.

NEW PROCESS FOR BUILDING UP SURFACES, REPAIRING CASING AND HOUSING CRACKS, ETC.

▲ The Mogul Nervous Weld Process is a new development of the Metallizing Company of America, 1330 W. Congress Street, Chicago, pioneer manufacturer of metallizing guns and equipment. This remarkable new process was developed primarily to solve the problem of reclaiming defective aluminum castings and can be used with equal success in salvaging bronze, grey iron, malleable and steel castings. Other important uses are the building up of surfaces for press fits, the repair of cracked housings, motor blocks, pump housings, as well as the preparation of surfaces for metallizing.

A complete installation to do this type of repair includes a Mogul Nervous Weld Pistol which requires approximately 60 pounds air pressure at 4 to 5 cubic feet per minute and a Mogul Nervous Weld Machine, 110, 220, 440 volts, 60 cycle or 25 cycle, single phase. The latter unit is completely equipped with two 10 foot lengths of cable, male and female receptacle, pair of goggles, heavy duty ground clamp, 20 foot length air hose complete with fittings, wall receptacle and complete instructions.

The Mogul Nervous Weld Pistol deposits atomized particles of metal which are welded to the surface and pressed leaving a metal which is welded and forged.

Designed for manual operation, the rod (aluminum, bronze or nickel) is fed through the pistol by a trigger control and it is possible to feed 1/8 in. to 3/8 in. with one stroke of the finger-grip trigger.

One of the advantages of the Mogul Nervous Weld Pistol is that it eliminates stresses and distortion in the repair of defective aluminum castings. The temperature never rises above 125 F and yet provides a deposit so dense at the point of fusion that there is no apparent line of demarcation. Even photo-micrographs fail to show the line of demarcation. Aluminum castings, repaired with this unit, machine perfectly and withstand sodium hydroxide solutions used to prepare castings for alumilite plating.

Operating features of this new unit include power chamber and peening motor, air-cooled nozzle, which keeps electrode as well as the work cooled, finger trigger which permits manual wire feed, needle valve to regulate air supply and electrode lug-connector. For further information write direct to Metallizing Company of America, 1330 West Congress Street, Chicago 7, Illinois.

BENDING, STRAIGHTENING MACHINES MODERNIZED

▲ A new line of bending and straightening machines, in six sizes having capacities ranging from 50 to 400 tons for cold bending and straightening structural shapes and other metal forms, has been announced by Thomas Machine Manufacturing Company, Pittsburgh, Pennsylvania. Beams, channels, rails, shaftings, rounds, squares, forgings, structural sections, or any metal sections that require bending or straightening can be handled by the machines. Weighing from 3800 to 55,000 lb, the machines can bend and straighten 5 in. to 24 in. beams.

The Thomas bending and straightening machine eliminates the wasteful process of heating beams or shapes, staking them out on a bending table, and having work gangs hammer them to the desired shape. Since the work is performed cold, no furnace is required and one man easily handles the operation.

Modernized throughout, with important mechanical improvements, welded steel frame, and entirely enclosed operating machinery, the new line replaces previous Thomas' bending and straightening equipment.

A continuously running ram with one bending block, striking against the shape to be bent midway between two bearing blocks, represents the operating principle of the machines. The length of stroke of the ram is quickly adjustable by a convenient hand-wheel so located the operator has unobstructed view of his work.

Free running table rollers, with anti-friction bearings, support material being passed through the machine. An auxiliary spacer block for bending small sections is furnished.

Other construction details include flywheel, in anti-friction bearings, located within the frame for safety and to eliminate overhead load on bearings; V-belt drive providing quiet operation and reducing shock load on motor; cast steel gears and steel pinions, all having cut teeth, with gear covers provided; high carbon steel forging cam shaft.

Frames are of rolled steel plate with heavy cast steel throat filler and bending table welded into place. Bending blocks are cast steel. High pressure fittings supply lubricant to all bearings and slides; and bearings are bronze bushed.

Thomas Machine Manufacturing Company Bulletin No. 315, issued concurrently with this announcement, gives a description of the new bending and straightening machines with illustrations and technical data.

STAINLESS STEEL TUBE PRODUCTION SPEEDED UP

▲ Because the time for making a strong, corrosion-resistant, stainless alloy steel tube has been cut by a new industrial process, the production of submarines in the United States has been facilitated, according to Peter D. White, vice-president and general manager of the Babcock and Wilcox Tube Company at Beaver Falls, Pennsylvania.

Mr. White states that the company's method of making the 40-foot

seamless high alloy tube in its specialty tube plant had cut production time to about 15 per cent of the time needed to produce the tube by forging methods, which was the standard technique of making such tubes until a year ago. The tubing, which is used for making antennae masts, is the largest individual piece of stainless steel tubing that has been manufactured in production quantities sufficient to meet the U. S. Navy's building program.

Previously the production of antennae masts, periscopes and drive shafts had caused serious bottlenecks in the overall output of submarines. By the use of a simple and ingenious mill operation in the tube manufacture, the Babcock and Wilcox Company was able to slash the time required to make antennae masts, despite the obvious difficulties in producing a tube of this size and exacting requirements. The unfinished tube from which the antennae masts are made is 40 feet in length, six inches in diameter with a .600 inch wall, and weighs over 1450 pounds.

The company undertook the work of supplying the antennae mast tubing at the request of the U. S. Navy in June 1942. Two years ago the largest stainless steel tube that had been produced commercially weighed only a thousand pounds. Facilities for making this extremely long tube are very limited in the United States, and the company began the work only on an experimental basis. By October of that year the first tube was completed and shipped and two months later the company received the first report of its successful field use for antennae masts. By spring, the tubes were rolling off the mills at regular commercial production rates.

NEW LINE OF INDUCTION MOTORS ANNOUNCED

▲ A new line of large, heavy-duty induction motors is announced by Electric Machinery Manufacturing Company, Minneapolis, for all types of industrial, power plant, water works and other drives. Motor sizes range from 200 hp to 1000 hp, and are available in squirrel cage and wound rotor models. Special electrical and mechanical modifications can be supplied to meet specific power service and motor application conditions.

The heavy, reinforced motor frame construction is of fabricated steel plate, or close-grained cast iron depending on the size and type of motor. Form-wound stator coils have multi-layer insulation with high dielectric strength and moisture resistance, and is somewhat pliable to withstand the strains of heavy service. High thermal capacity, brazed cage winding — practically indestructible — on squirrel cage motors. Well insulated, strongly braced rotor winding on wound-rotor motors.

Directed, smooth-flow ventilation for cool motor operation is provided by rotor fan and conical baffling. Large motor shaft is accurately machined and finished. Modern, one-to-one ratio sleeve bearings are standard. Ball or roller bearings can be supplied. Protective enclosure for drip, splash, or other special conditions, and enclosed construction for direct ventilation, can be furnished. Write for Publication 169.

PLASTIC GOGGLES

▲ New all-plastic goggles, "Looks," have been announced by Mine Safety Appliances Company. "Looks" goggles, featuring light weight, wide vision and comfort, are suitable for both men and women, and provide comfortable, durable protection for the eyes, according to M. S. A.

Designed with individual eye cups molded to fit the facial contours, the goggles provide a close yet comfortable seal around the eye orbits. Large "aviation-type" lenses afford a wide, unobstructed angle of vision.

The strong, clear plastic frame is available in two styles: the general purpose model, providing direct ventilation through holes at the top and bottom of the eye cups, and the dust model, with indirect ventilation through serrated lense seats. All lenses are of polished sheet acetate, clear or green in color, and are quickly and inexpensively replaced. A wide elastic headband holds the goggle in place at low tension, assuring wearing ease over long periods of time.

Further details on "Looks" goggles are available in Bulletin No. CE-25, copies of which are available from Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, Pennsylvania.

NEW MARKERS AVOID STRESS CONCENTRATION

▲ A new and revolutionary style of rounded face characters, of special design, has been developed by Jas. H. Matthews and Company for engraving on steel stamps, steel dies, and type for marking of parts placed under torsion, tension, bending or any combination of these, or where heat treating is accompanied by cracking or breaking due to stress concentration, incident to conventional marking with sharp face stamping tools.

The new rounded face and special character design provides a minimum of set-up stress, and can be supplied in single letter and figure stamps, stamping dies for use in foot or power operated presses, and roller dies for use in all types of marking machines and in steel type for use in steel type holders. Also, in multiple character

stamps for marking flat, concave or convex surfaces.

Another outstanding feature of the new character design, is that it can be supplied in stamps, dies or type holders to control the depth of the mark. "Lo-Stress" stamping tools with controlled depth feature are being successfully used in the marking of thin sheet aluminum, steel, etc., where .003 to .006 in. depth of stamping must be maintained. "Lo-Stress" marking tools can be supplied for any desired marking depth to suit the stamping application.

New literature, designated as Bulletin A-2, in which complete information and illustrations of the various styles of marking tools using the new "Lo-Stress" character engraving are shown, is now available upon request.

New Literature

▲ It is a well known fact that the welding and cutting industry, ever since its inception, has always been several steps ahead of industry in general in matters of safety. Further concrete evidence of this alertness and leadership in the safety field is shown by the publication of an attractive 32-page booklet entitled "Safety in Electric and Gas Welding and Cutting Operations."

This is another in the series of American War Standards developed by the American Standards Association. Its preparation was initiated by the International Acetylene Association, the American Welding Society, the National Electrical Manufacturers Association, and the Division of Labor Standards of the U. S. Department of Labor. The booklet is designed to serve as a guide for the protection of the individual operator from injury or illness, and for the protection of property from fire or other damage arising out of improper methods in the installation, operation, or maintenance of welding and cutting equipment. It covers every phase of safety applicable to all ordinary welding, cutting, brazing, lead burnings, and flame-treating operations. It does not attempt to cover any special hazards which may be inherent in the operations of special industries such as explosives manufacturing or shell-loading. Copies may be purchased from the American Standards Association, 29 West 39th Street, New York 18, New York.

▲ A new booklet, "Submerged Combustion," sets forth the advantages of submerged direct-fired burners for heating and agitating pickling solutions and for evaporating liquids. Increased production, lower heating costs, lower acid costs and low maintenance costs are among the advantages claimed. Copies of the booklet may be had by writing Submerged Combustion Company of America, Inc., Hammond, Indiana.

▲ A four-page booklet just issued by Pittsburgh Plate Glass Company, Grant Building, Pittsburgh, Pennsylvania, describes the uses of Columbia soda briquettes for blast furnace and foundry plants, and of Hennig Purifier in open hearth and bessemer practice. Copies are available upon request to the company.

▲ The Herman H. Sticht Company, Inc., of 27 Park Place, New York 7, New York, has issued a new bulletin No. 435 describing the model B-5 Megohmer, battery-vibrator type insultation tester. The new bulletin shows the triple color scale, the various models available, and contains a chapter on the value of periodic insulation resistance measurements as recorded on megographs.

▲ For tool engineers, manufacturers and production men studying new techniques and methods of manufacture, a new 32-page catalog on reaming operations and their effect on final cost has just been published by the Madison Manufacturing Company of Muskegon, Michigan.

Keynoting the entire publication is the simplicity of design and operation of Madison adjustable reaming tools. A one-screw adjusting feature allows a precision adjustment of the Madison cutter with an ordinary screw driver. The Madison bar permits the cutter to be floated directly at the point of its insertion in the bar, eliminating the cost of high priced floating tools holders and chucks. Interchangeability of cutters in the bar through presizing, gives the operator a more versatile tool, allowing many different diameters to be reamed with one bar and a number of cutters. This feature also omits disturbance of the original set-up when cutters need resharpening.

Complete data on grinding instructions and reamer used, completes this new catalog and adds interest for those manufacturers planning on rock-bottom efficiency to gain them an advantage in a highly competitive market. Write for catalog No. 21.

▲ Elimination of the hazards due to the manual lubrication of high-up and hard-to-get-at bearings on presses, cranes and other "off the floor" types of equipment is the subject of an illustrated bulletin just issued by The Farval Corporation, Cleveland, Ohio, under the title "Aloft is no Place for A. W. O. L. (absent without lubrication) Bearings." The bulletin explains the application of the Farval Dualine system for sending lubricant under pressure from a central pumping unit to every bearing on the machine. The dangers of personnel accidents, as well as shutdowns caused by faulty lubrication by hand, are contrasted with the safety and certainty obtained through the Farval method. The bulletin concludes with a page illustrating the various types of Farval systems with a typical application of each system.

▲ A new condensed catalog covering all South Bend lathes has just been issued by the manufacturer. This eight page, file size catalog illustrates and describes engine lathes, toolroom lathes, and precision turret lathes for practically all types of production, toolroom, and maintenance work.

The engine lathes and toolroom lathes are made in five sizes with 9 in., 10 in., 13 in., 14½ in., and 16 in. swing, and with bed lengths from 3 ft to 12 ft. The precision turret lathes have 9 in. and 10 in. swing with ½ in. and 1 in. maximum collet capacity. To facilitate the use of this catalog, all information concerning capacities, speeds, feeds, and dimensions are tabulated for each size and model of lathe. Considerable space is devoted to lathe attachments for special classes of work.

Copies of this new catalog, No. 150, can be obtained by writing to the South Bend Lathe Works, South Bend 22, Indiana.

▲ A new bulletin, "Hold Everything," issued by Microcopy Corporation, 2800 West Olive Avenue, Burbank, California, describes a new and improved application of microfilming to pencil engineering drawings made on transparent paper, as well as other valuable records, documents, drawings, maps and materials.

The bulletin points out advantages in time, savings in money, and document-insurance features provided by the Microcopy microfilming process, known as the Translite Hi-Reduction Microfilm process.

The bulletin, illustrated, demonstrates savings in space provided by the service, as well as describing the

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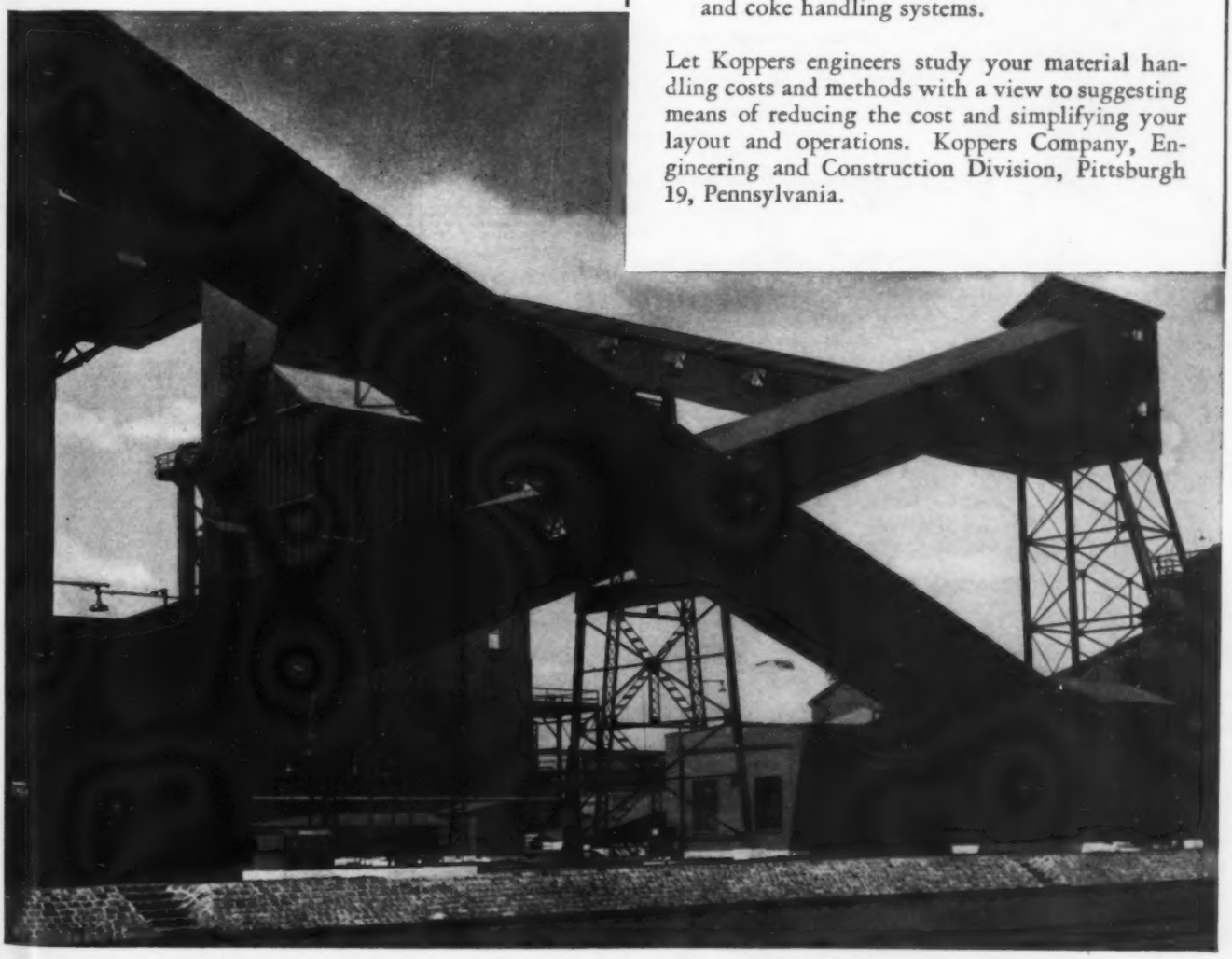
3. Open hearth slag crushing and screening plants.

4. New systems for handling and storing coal and coke at coke ovens. These systems may include equipment for car unloading, weight mixing of coals, and bulk density control of coals to be charged to the ovens. Plans will also be submitted for modernizing existing coal and coke handling systems.

Let Koppers engineers study your material handling costs and methods with a view to suggesting means of reducing the cost and simplifying your layout and operations. Koppers Company, Engineering and Construction Division, Pittsburgh 19, Pennsylvania.



new Microcopy multiple-magnification viewer for reading Microcopy reproductions on film.

▲ Bulletin No. 27-A illustrates and describes a modernized line of wick feed oilers supplying visible, automatic lubrication to solid, wick and waste-packed bearings. Helpful hints on how to eliminate needless shutdowns for hand-oiling, end bearing failures, splattering of oil, etc., are given. The plastic reservoir has reinforced ribs for extra strength. Oiler is 50 per cent lighter in weight and has four times the capacity of ordinary oilers for the same space utilized. Available in 1, 2, and 4 oz capacities. Write for your free copy. Trico Fuse Manufacturing Company, 2948 No. 5th Street, Milwaukee 12, Wisconsin.

▲ Air Reduction, producer of welding equipment and supplies is now distributing a new thirty-two page booklet "New and Improved Oxyacetylene Methods for Steel Foundries." Profusely illustrated, the booklet, as its name implies, describes numerous new and improved methods of performing common steel foundry operations by the use of the oxyacetylene flame. Principal stress among the methods described is laid on the removal of risers by machine flame cutting. A number of examples of this practice are illustrated and comparisons are drawn with the hand torch method of riser removal.

Other processes treated in the booklet include: flame scarfing to remove pads left after riser removal; flame gouging for the removal of webs, fins and defects; flame descaling for cleaning normalized or annealed castings; flame lancing and its various uses in the steel foundry, and flame hardening for the localized hardening of steel castings. In a number of instances, actual comparisons with former methods of performing the work show important economies effecteD by the processes described. Also included in the booklet is a section describing and illustrating equipment recommended for the various processes. Copies ofthe booklet may be obtained from Air Reduction sales offices located in principal cities or by addressing Air Reduction, 60 East 42nd Street, New York 17, New York.

▲ The Meehanite Research Institute of America, Inc., Pershing Square Building, New Rochelle, New York, has published a new bulletin No. 19 entitled "Meehanite Castings vs. Welded Construction." The four-page piece illustrates comparative castings and welded fabrications for the same parts on diesel engines and heavy-duty press construction. Cost and weight comparisons are given. Copy will be sent free upon request.

▲ An informative new bulletin, entitled "A Blow without a Dent," shows and describes the Basa replaceable face hammers and the Empire soft face mallets manufactured by Greene, Tweed and Company, New York.

A feature of special interest displayed in this bulletin are the plastic faces and heads which are now available for these hammers and mallets. The bulletin concisely outlines the particular advantages of the special material selected for the purpose, and explains why this plastic is superior to many other materials in various uses of the tools. Rawhide, copper or

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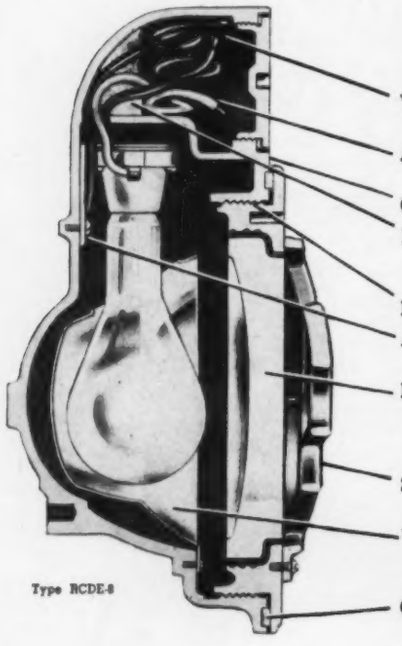

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babbitt faces can also be furnished for the Basa hammers, and plain or loaded rawhide heads for the Empire mallets.

In addition, the bulletin outlines the various distinctive features of these tools, including the split adjustable heads of Basa hammers which enables the interchangeable faces to be replaced within a few seconds, and the carefully distributed weight of both hammers and mallets which permits blows to be struck without transmitting shock which would cause fatigue of the user.

Copies of the bulletin can be obtained by addressing Greene, Tweed and Company, Bronx Boulevard at 238th Street, New York 66, New York.

▲ Much greater fuel economy or greater steam generating capacity can be obtained by modernizing baffles and furnaces.

The Ramtite Company's new bulletin explains and illustrates how significant economy can be effected by proper design. It presents blueprints showing the old and new location of baffles together with an account of savings made in each case. The bulletin, entitled "Economy Boiler Baffles," may be obtained from The Ramtite Company, Division of The S. Obermayer Company, 2563 West 18th Street, Chicago 8, Illinois.

▲ Wheelco Instruments Company, Harrison and Peoria Streets, Chicago 7, Illinois, has announced a new edition of its Wheelco thermocouple data book and catalog, bulletin S2-4. Containing 36 pages, the catalog gives a description of products, prices and recommendations for thermocouple users, and suggests substitutes for restricted materials. It carries the latest amendment to the WPB's Conservation Order L-134, and gives data on selection of thermocouples, lead wire, protecting tubes, heads and insulators. Also carried are temperature conversion tables, millivolt tables, and tables on pipe and wire sizes, decimal equivalents and wire resistances. Instructions are given on checking thermocouples and pyrometers, and on construction of thermocouples.

▲ Bardwell and McAlister, Inc., Hollywood, 28, California, describe the Rosan locking system for threaded inserts and studs in two new booklets. By means of this system, threaded inserts and studs can be solidly locked in hard or soft materials so that they will not turn or loosen under vibration and will not back out while removing a tight nut.

▲ A complete bulletin on Saflex plug-in duct, Saflex feeder duct, Square-duct and screw cover duct for electrical distribution systems, includes complete description and application data, price information and understandable illustrations. 36 pages. Write Square D Company, 6060 Rivard St., Detroit 11, Michigan.

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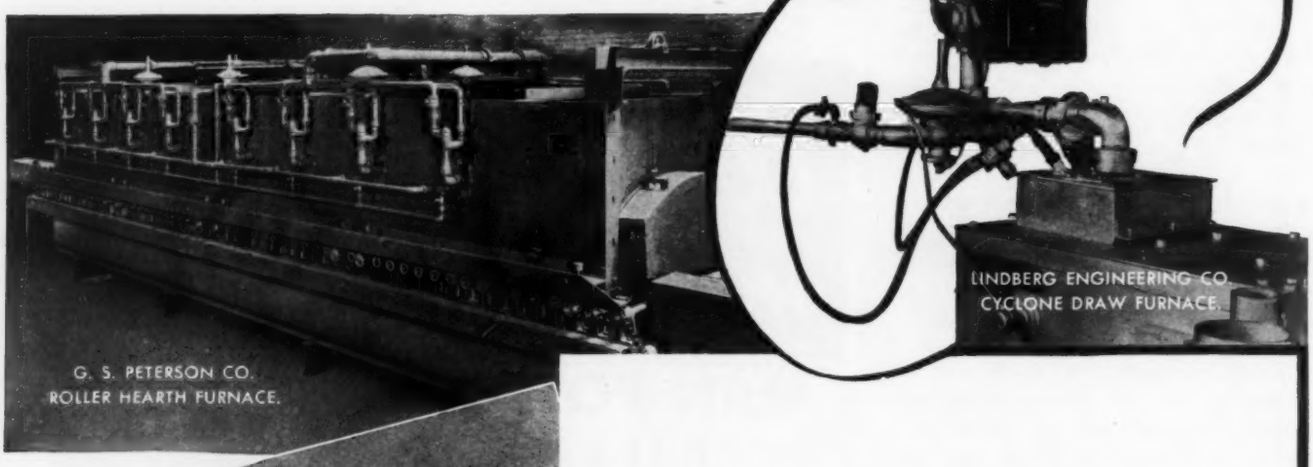

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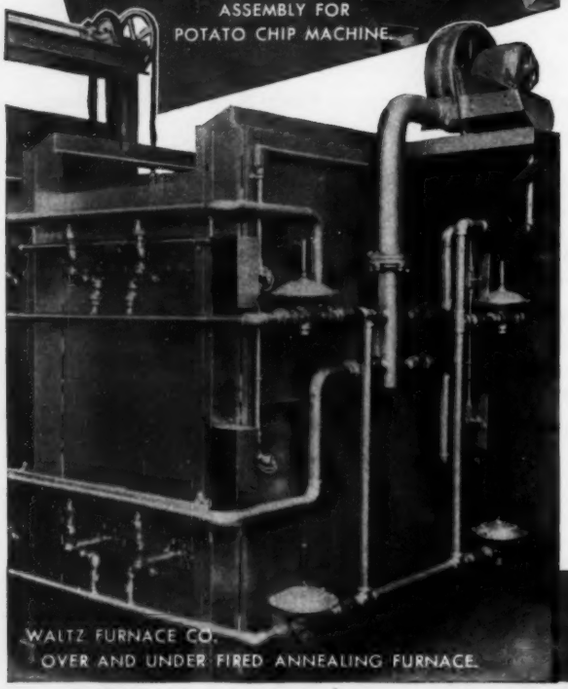

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Personnel News

J. S. Murray, chief electrical engineer, Follansbee Steel Corporation, and vice-president of the Association of Iron and Steel Engineers, has been appointed a member of the American Iron and Steel Institute subcommittee on electrical steel sheets. This committee is cooperating with N. E. M. A. and A. I. E. E. in formulating values of test of all grades electrical sheets ar 15 kg. Mr. Murray is also a member of A6 committee A. S. T. M. on magnetic materials.

Harold J. Ritter has resigned as vice-president and director of the Norma-Hoffmann Bearings Corporation, Stamford, Connecticut. Mr. Ritter has been with the Norma-Hoffmann Bearings Corporation for 28 years, beginning his career there as secretary to the founder of the company, the late W. M. Nones. He has occupied various capacities with the company during that time, having been made assistant secretary of the company in 1928, secretary in 1936 and finally vice-president in 1939. Mr. Ritter has been a director of the company since 1936 and has also occupied the post of sales manager since 1932.

D. E. Batesole has been named vice-president and chief engineer of the Norma-Hoffman Bearings Corporation. He has been a member of the firm's engineering department for over 25years, and has been chief engineer since 1937.

David M. Kelly has been appointed to the engineering staff of the John C. Dolph Company, Newark, New Jersey, in charge of the Industrial Service Division. He was formerly associated with the I - T - E Circuit Breaker Company of Philadelphia, Pennsylvania.

Marcel A. Cordovi, formerly research assistant Welding Research Council of the Engineering Foundation, has joined the metallurgical staff of The Babcock and Wilcox Tube Company as research metallurgist.

Mr. Cordovi received his BME and MME degrees from the Polytechnic Institute of Brooklyn where he held a Graduate Fellowship in 1941 and worked on numerous research projects with Professor Otto H. Henry.

J. Edward Donnellan, widely known in the metal field for his work with the American Society for Metals has resigned from that organization to join the General Alloys Company as vice-president in charge of sales. Since his graduation from Pratt Institute, Brooklyn, as an industrial chemical engineer, Mr. Donnellan has been directly associated with the metal industry. In 1924 he joined the American Society for Metals and was named secretary to its National Technical Committees, the position in which he served for the past twenty years. He is probably best known for his work as editor of the nationally known Metals Handbook.

R. L. Hanson has been appointed manager of the Pittsburgh office of the Crocker-Wheeler Electric Manufacturing Company, Ampere, New Jersey. Mr. Hanson succeeds **J. R. Lewis** who has retired from the managership of this office to devote his entire time to special assignments. Mr. Lewis, in connection with this work will be designated as special representative.

Harry A. Fennerty has been elected president, Alliance Machine Company, Alliance, Ohio, succeeding the late W. H. Purcell. **G. W. Shem,** director and president of Alliance Structural Steel Company, has been named board chairman of Alliance Machine Company. Other new appointments are: **R. J. Harry,** vice-president; **R. R. Stuckey,** secretary, and **B. A. Tuttle,** treasurer.

ALAN D. DAUCH

Alan D. Dauch, vice-president of the George J. Hagan Company, Pittsburgh, Pennsylvania, was elected president of the Industrial Furnace Manufacturers Association at its recent conference at Seaview Country Club, Absecon, New Jersey.

H. O. Teeple, chemical engineer, has joined the Technical Service Group of the Development and Research Division of The International Nickel Company, Inc., New York, New York. He will specialize in corrosion problems.

After graduation from the University of Michigan in 1937, Mr. Teeple became associated with the alkali and chlorine products industry, remaining there until coming to International Nickel. He has had experience in production, process control, and maintenance engineering, including equipment specifications, corrosion control and the use of metals, alloys, plastics, and special paints.

A. H. Kruger, associated with the industrial heating and processing industries for the past 19 years, has joined Wheelco Instruments Company, Chicago, as application engineer. Mr. Kruger will be engaged primarily in introducing to the industrial heating and processing industries the Wheelco Company's new line of instruments. He was among the first to apply automatic temperature and furnace pressure controls to

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Oil Immersed

MOTOR CONTROL

BY USERS EVERYWHERE

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

industrial furnaces and boilers, and since 1941 was vice-president in charge of sales and estimating for the Vulcan Corporation.

William H. Seaman, president and general manager of the National Roll and Foundry Company, Avonmore, Pennsylvania, has become chairman of the board, succeeding **R. Howard Webster** in the latter position.

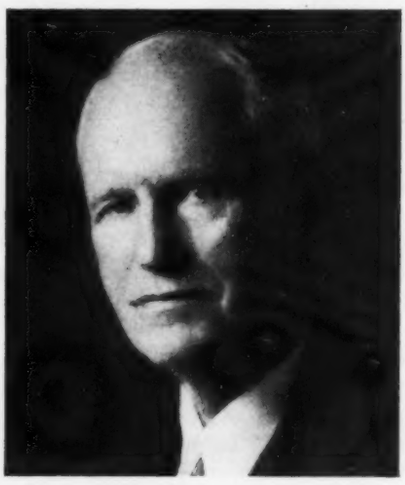
Richard J. Buck has resigned as vice-president, but will remain as director of the company.

Colin W. Webster and **J. A. Weingart** have resigned as directors and are succeeded by **C. N. Buchholz,** controller, and **E. R. Pierce,** general superintendent.

Donald H. Baum has been elected as a director and vice-president in charge of sales.

Obituaries

W. H. Purcell, founder and president of the Alliance Machine Company, Alliance, Ohio, died May 28th at the age of 79.



W. H. PURCELL

Mr. Purcell started his career as an apprentice machinist at the Morgan Engineering Company in 1882. Progressing to foreman, superintendent and general manager, he left Morgan in 1901 to establish the Alliance Machine Company, serving as president from the beginning until his death. Under his guidance, the firm became one of the leading builders of electric traveling cranes and other heavy machinery, pioneering in many improvements in design and safety of present day cranes.

Mr. Purcell was very active in industrial and civic affairs. He was a member of the Association of Iron and Steel Engineers since 1911.

Benjamin J. Harlan, vice-president and general manager of the Lone Star Steel Company, Daingerfield, Texas, died suddenly at Hot Springs, Arkansas. He was 49.

Mr. Harlan was a graduate of Vanderbilt University and the Sorbonne in Paris, and served in the Engineers Corps in the World War. He had been employed by the Midvale Company and for 20 years was associated with the Bethlehem Steel Company in Johnstown and Buffalo.

C. C. Levy, of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania, died suddenly at his home in Wilkinsburg on June 5, 1944.

Mr. Levy was born in Jamaica, British West Indies. He took his preparatory course at Jamaica College and studied electrical engineering at Toronto University,

C. C. LEVY

Canada. He joined Westinghouse in 1913 as a draftsman. Two years later he was made a design engineer on automatic substation equipment.

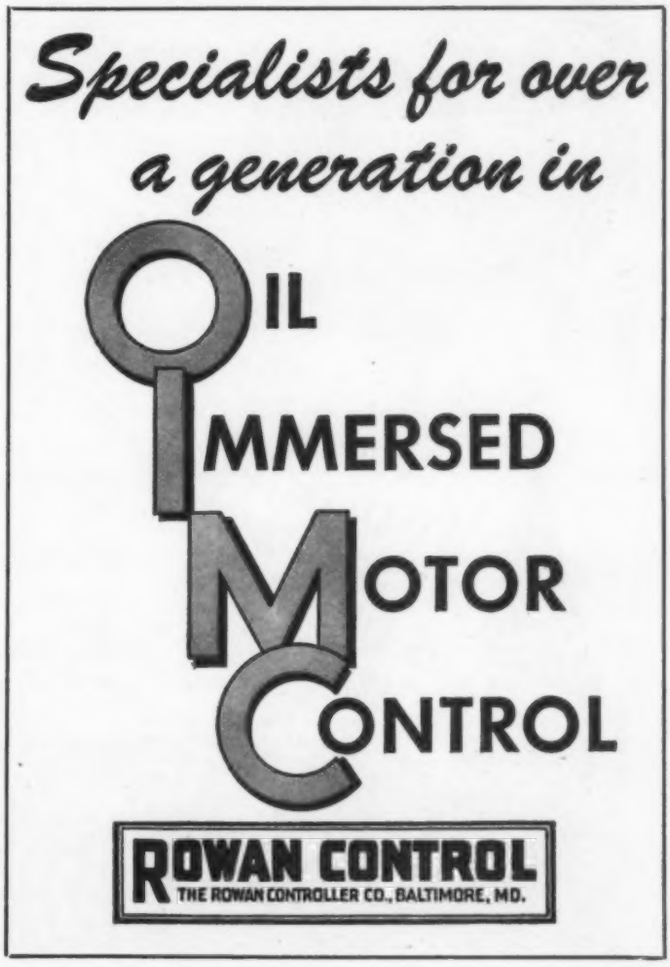
In 1930 he was transferred to Industry Engineering Department where he handled the application of electrical apparatus in the electro-chemical industry. During this period he assisted in the development of electronic equipment to clean gases and assisted in the selection of electrical apparatus for large electrolytic installations.

In 1941 he was transferred to the Metal Working Section of Industry Engineering where he had charge of the application work on the newly developing field of high frequency equipment and the rapidly expanding program of electric furnace installations.

Mr. Levy sponsored the application of specially designed air circuit breakers for electric arc furnace applications, and more recently guided the development of regulators for electric arc furnaces. He made a number of valuable contributions in this field.

n·B·m BRONZE AND COPPER CASTINGS
Blast Furnace Copper Castings • Roll Neck Bearings • Housing Nuts • Machinery Castings • Acid Resisting Castings • Phosphorized Copper • Locomotive and Car Journal Bearings • Babbitt Metals
NBM
NATIONAL BEARING METALS CORP.
ST. LOUIS • PITTSBURGH • NEW YORK

IMO
Reliability
IN NAVAL
SERVICE
The reliability of IMO "lube" and fuel oil service pumps is typified by their trouble-free performance on a United States Destroyer reported to us by the Navy as having steamed over 84,000 miles on convoy duty during the past year, often cruising as much as 28 days per month without time for normal upkeep and overhaul.
Ask for Catalog I-115
IMO PUMP DIVISION
of the De Laval Steam Turbine Company, Trenton 2, N. J.



FOR THOSE "TOUGH JOBS"

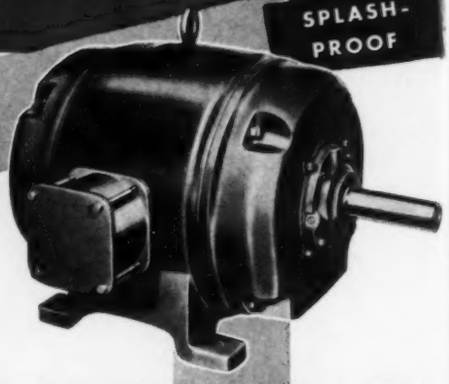
WHERE THE SURROUNDING ELEMENTS ARE DESTRUCTIVE OR HAZARDOUS

use Wagner MOTORS

TOTALLY-ENCLOSED

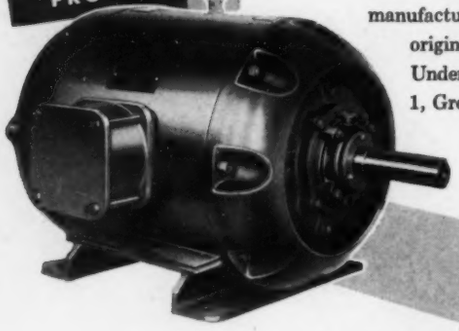
Wagner CP totally-enclosed fan-cooled motors are designed to operate under adverse conditions in atmospheres that contain dust, dirt, abrasives, steel chips, filings, acid fumes, and other harmful elements.

SPLASH-PROOF



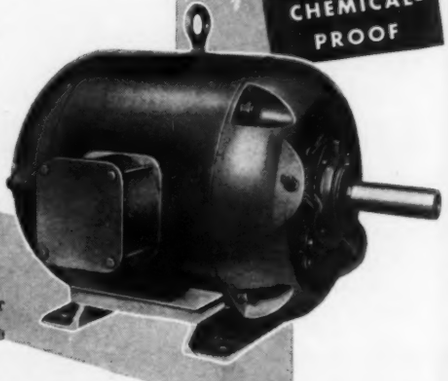
Wagner splash-proof, squirrel-cage polyphase motors are built to operate dependably in locations where they are subject to splashing water, oil, or other liquids. They are widely used in unprotected outdoor locations, being designed with complete self-protection against rain, snow and sleet.

EXPLOSION-PROOF



Wagner explosion-proof polyphase motors are designed to operate in locations where "flammable volatile liquids, highly flammable gases, mixtures or other highly flammable substances are handled or manufactured, used or stored in other than original containers." Approved by the Underwriters' Laboratories for Class 1, Group D hazardous locations.

CHEMICAL-PROOF



Wagner chemical-proof motors are of totally-enclosed, fan-cooled construction and designed to resist the action of acids, fumes, moisture and other harmful elements encountered in chemical manufacturing. A moisture-proof and dust-tight conduit box protects the motor against dust, fumes, or moisture. Special drain plugs in end-plates and conduit box are provided for removing any condensation from the motor or conduit box.

MOTORS
TRANSFORMERS
UNIT SUBSTATIONS
INDUSTRIAL BRAKES
BRAKE LINING

M44-8

Write **FOR BULLETINS MU-182 and MU-183**

Everyone interested in electric motors should have Wagner Bulletins MU-182 (Wagner Polyphase Motors) and MU-183 (Wagner Single-Phase, Direct-Current, and Small Polyphase Motors). Helpful information also will be found in Bulletin MU-26A (Instructions for Installing and Operating Wagner Polyphase Motors).

ARMY (E) NAVY

NATIONAL SECURITY AWARD

Wagner Electric Corporation

ESTABLISHED 1891

6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS

NEW 3/8" — 2, 3, or 4 WAY AIR VALVE

FEATURES

1—Hinged armature operating magnet
2—Slide valve type
3—Valve parts removable without any piping disturbance
4—Bronze valve body
5—Nitralloy valve plunger
6—Air leakage cannot cause pressure build-up in "off" cylinder
7—Continuous duty operating coil
8—Pipe Connections available in bottom or through the side.

★ "3C" Bulletin 5740 Magnet Operated Valves are designed for use on air operated welders, tools, etc.

The hinged armature magnet has very little movement, and a minimum of pounding. It is a slightly modified standard "3C" magnet which has been used for years as a heavy duty contactor operator.

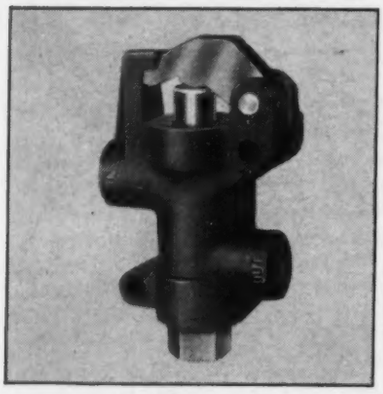
This sturdy valve is designed to give 400 operations per minute. Ample size of bronze stationary valve body and nitralloy moving plunger provide long life with little wear.

For complete details ask for Bulletin 5740

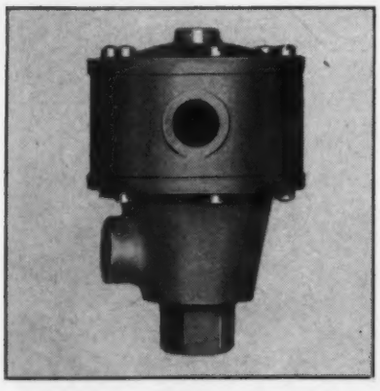
OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

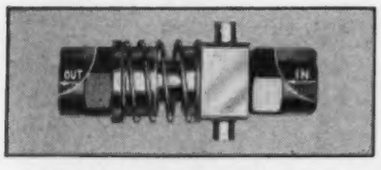
1146 EAST 152ND ST. CLEVELAND, OHIO



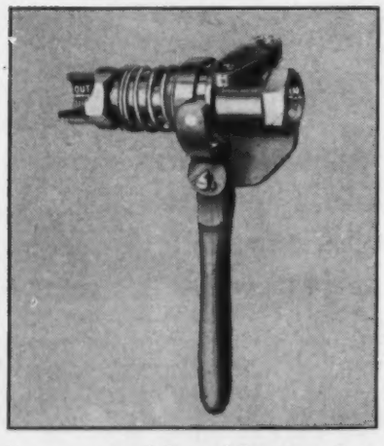
Cam operated 2- and 3-way types.



Diaphragm operated 2- 3- and 4-way types.



Mechanically operated 2- and 3-way actions.



Lever operated 2- and 3-way actions.

Keep MACHINES IN FAST *Production*

WITH

Quick-As-Wink

CONTROL VALVES

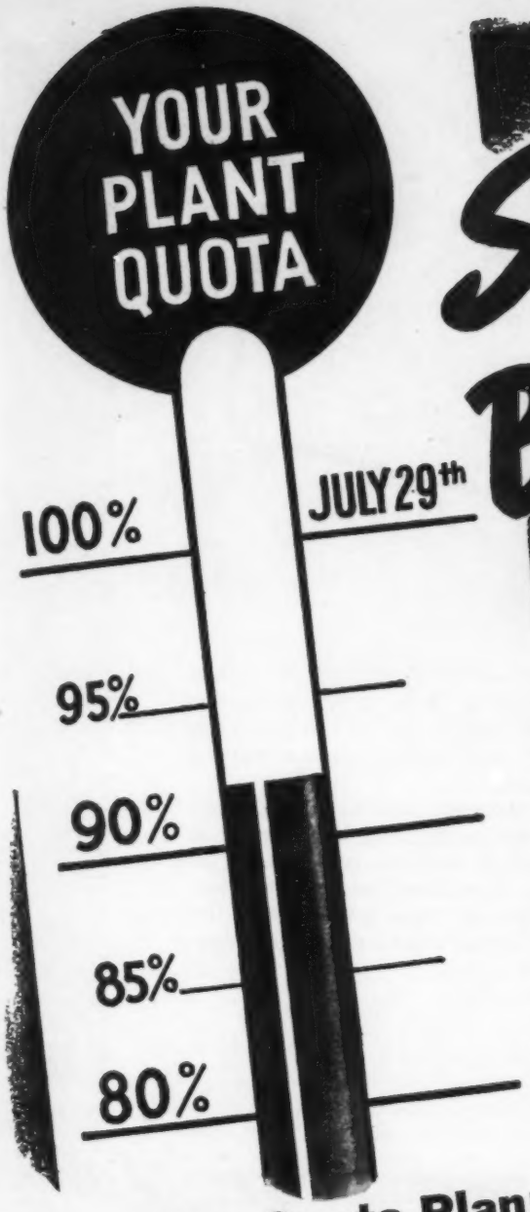
Q.A.W. valves are doing valiant service in war work by promoting faster operation and insuring uninterrupted production. They can be easily adapted to most any pressure control situation. They operate millions of times without loss of efficiency or requiring time out for servicing. Short travel and inherent balance in any position contribute to smooth, lively, easy action. Available in a wide range of types and sizes for practically any application.

Send for catalog and data book.

THE HIGHER THE PRESSURE
AIR
WATER
OIL
THE TIGHTER THE SEAL

C. B. HUNT & SON

1863 EAST PERSHING STREET - SALEM, OHIO



Stay at Your Battle Stations!

MANAGEMENT • LABOR

—the 5th War Loan Drive is still on.

July 29th is the last pay day in the Drive.

The U. S. Treasury has set the overall goal at $16,000,000,000 —$6,000,000,000 from individuals alone. This is the biggest sum ever asked of the American people—*and it must be raised!*

Keep fighting. The 5th War Loan is a crucial home front battle of tremendous importance to the total war effort.

Tighten up your 5th War Loan Drive organization. Step up your solicitation tempo. Drive! Drive!! Drive!!! Hit your Plant Quota's 100% mark with a bang that'll proclaim to all the world that the U. S. Home Front is solidly in back of the Fighting Front.

Need help? Need ideas? Call on the Chairman of your War Finance Committee. He's standing by.

Here's the Quota Plan:

1. Plant quotas are to be established on the basis of an *average* $100 *cash* (not maturity value) purchase per employee.
2. Regular Payroll Savings deductions made during the drive accounting period will be credited toward the plant quota.
3. Employees are expected to contribute toward raising the cash quota by buying extra 5th War Loan Bonds: 1—Outright by cash. 2—By extra installment deductions. 3—By extra installment deductions plus cash.

Example: JOHN DOE MFG. CO.—1,000 Employees

1,000 Employees x $100 . . $100,000 Cash Quota

Regular payroll deductions during the eight weekly payroll accounting periods of June and July. 30,000

$70,000 (to be raised by sales of extra Bonds).

BACK THE ATTACK—SELL MORE THAN BEFORE

The Treasury Department acknowledges with appreciation the publication of this message by

IRON AND STEEL ENGINEER

★ ★ *This is an official U. S. Treasury advertisement—prepared under the auspices of Treasury Department and War Advertising Council.* ★ ★

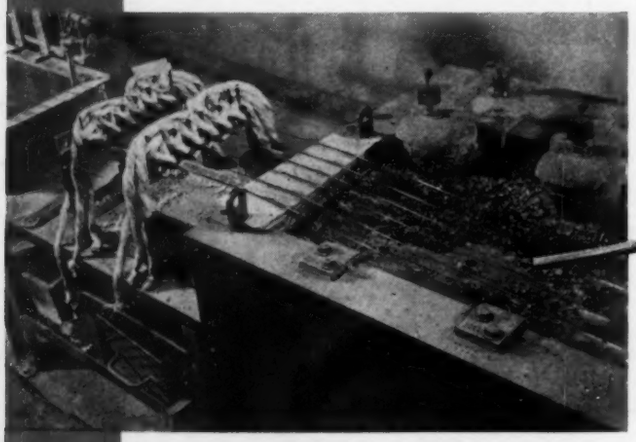
OKOLOY
was not drafted . . .
It volunteered in 1928

The war-caused shortage of tin forced many wire and cable manufacturers to search hurriedly for substitutes to replace the tin coating on conductors to prevent chemical reactions between the copper and rubber insulation.

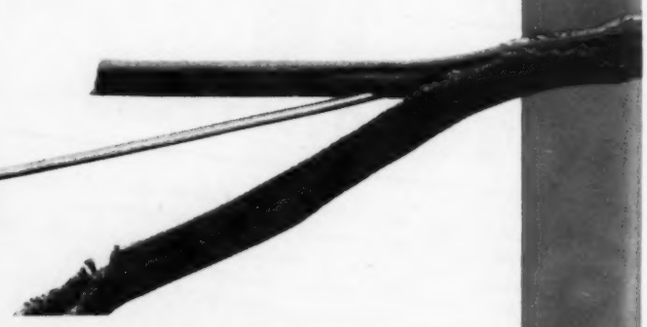
In 1928, however, Okonite chemists, constantly discontent with run-of-the-mill practices, had developed and perfected Okoloy, a lead alloy coating that outlasts tin at least 2 to 1.

The old practice of "tinning" the copper conductors by passage through a bath of molten metal gave inadequate protection and too often led to failure and premature deterioration of expensive cables.

No war-forced substitute, Okoloy, for sixteen years, has been used to protect the copper conductors of all Okonite rubber insulated cables. When you specify any Okonite cable, Okoloy is just one of the "plus benefits" you obtain.



LASTING PROTECTION: After electrolytic cleaning, all Okonite copper wire passes through the Okoloy bath where, under carefully controlled temperature, the corrosion-resistant Okoloy coating is bonded to the conductor.

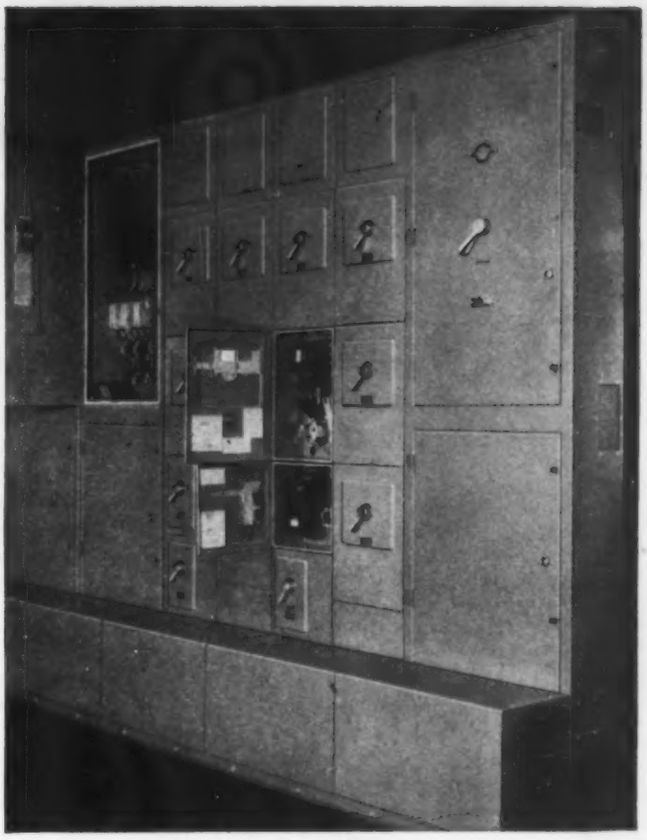


PROVED IN THE FIELD SINCE 1928: Section of Okoloy-coated wire removed for examination in 1941 after 13 years of service along right-of-way of a major railroad system, where it was continuously exposed to weather and to highly corrosive sulphur fumes. Note perfect condition of Okoloy coating and Okonite insulation.

THE OKONITE COMPANY, PASSAIC, NEW JERSEY

OKONITE INSULATED WIRES & CABLES

in TRUMBULL CONTROL CENTERS



☆ **EASIER to BUY in "modern" packages.** This is the NEW and better way to buy electrical control equipment. You order standardized stock units where once you had the expense and delay of "special engineering". You get exactly what you want for the job to be done . . . PLUS unlimited flexibility in planning for future extensions or changes.

☆ **EASIER to install.** Trumbull Control Centers can be installed in *hours* where old time installation took days or weeks. First, the prefabricated bus bar vertical sections, which carry power, are lined up and connected to mains. Then the necessary combinations of control units are simply "plugged in" to the sections. That's all there is to it. Installation may be back-to-back or flat against walls because everything is accessible from the FRONT.

☆ **EASIER to extend, rearrange or relocate.** Trumbull Control Center installations are as flexible in this respect as a "row of filing cabinets". You can add or remove sections; you can rearrange control units within the sections. You can rearrange the entire installation if your shop power requirements change in the future.

☆ **EASIER to provide adequate protection against shutdowns . . .** first through centralized group control that assures a uniformly high standard of electrical safety for *all* equipment in a department. Secondly, by isolating one department or plant section from another as far as electric power is concerned.

☆ **EASIER TO SERVICE.** All dead front construction . . . all units and entire mechanisms inspectable and removable *from front* . . . wiring connections easily made *from front.*

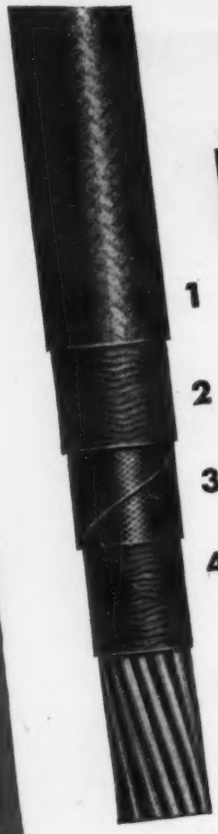
☆ **EASIER TO LOOK AT.** Thin cross section, totally enclosed, beautifully finished in machine gray enamel, Trumbull Control Centers are the "show pieces" of most plants where they are installed. Good looks are important . . . and especially so when they are the result of correct design, expert construction and high quality throughout.

Write for Trumbullaid Bulletin No. 411.

TRUMBULL
CONTROL CENTERS

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY • PLAINVILLE, CONN. • A GENERAL ELECTRIC ORGANIZATION

OTHER FACTORIES AT NORWOOD (CINN.) O. — SEATTLE — SAN FRANCISCO — LOS ANGELES



ROCKBESTOS A.V.C.

1 POINTS THE WAY TO LONG WIRE LIFE

2 exposed to severe operating conditions

3 in lighting control and power circuits

Rockbestos A.V.C. Power Cable above, and similarly insulated Motor Lead Cable (Underwriters' and Nat. Elec. Code, Type AVA) has a maximum operating temperature rating of 110° C. (230° F.) and this permanently insulated construction:

4

1. A tough, rugged asbestos braid, resistant to heat, flame, moisture, oil, grease and corrosive fumes.
2. Outer felted asbestos wall, also impregnated with heat, flame and moisture resistant compounds, serves as an effective barrier against high ambient temperatures and flame.

5

3. Lubricated varnish cambric for high dielectric strength and added moisture resistance, protected from heat, flame and oxidation between two impregnated asbestos walls.
4. Felted asbestos insulation, impregnated with heat-, flame-, and moisture-resisting compounds, withstands conductor heating overloads and won't dry out, bake brittle or burn.
5. The conductor is perfectly and permanently centered in helically applied insulation.

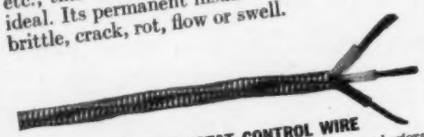
One of 122 different wires and cables developed for severe operating conditions by Rockbestos.

WON'T bake brittle, bloom, burn or rot.
RESISTS moisture, oil, grease and fumes.

ROCKBESTOS 600 VOLT A.V.C. BOILER ROOM WIRE
(Underwriters' Type AVA)

Sizes No. 18 to 4/0 AWG. This construction for sizes 18 to 8, sizes 6 to 4/0 have another wall of felted asbestos next to the conductor.

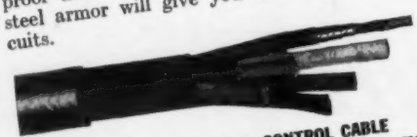
For lighting and control circuits exposed to heat and moisture, oil, grease, corrosive fumes or fire hazard, such as exist around furnaces, ovens, lehrs, soaking pits, boilers, etc., this widely used A.V.C. construction is ideal. Its permanent insulation will not bake brittle, crack, rot, flow or swell.



ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", or .025" or (for 115 volt service) .031" of felted asbestos insulation and steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal, and temperature control systems. Its lifetime heatproof and fireproof insulation and rugged steel armor will give you troubleproof circuits.



ROCKBESTOS 600 VOLT A.V.C. CONTROL CABLE

In one to 19 conductors. Standard stranding AWG No. 12—19/#25 and No. 9—19/#22. Other strandings furnished.

Designed for use under conditions too severe for control cables with other types of insulation which deteriorate rapidly when exposed to high temperatures. Operates without failure under the attack of heat, oil, grease or corrosive fumes and may be installed in conduit as it has ample moisture resistance.

Looking for a wire with a tough enough insulation to give years of trouble-free service in hot locations? Around forging presses, soaking pits, steam tunnels, lehrs, kilns, hot strip mills? In locations where heat, moisture, grease, fumes, etc. are playing hob with your present wires? Then investigate Rockbestos A.V.C.

Designed specifically for operation under severe conditions and in "hot-spot" locations, these Rockbestos A.V.C. wires, cables and cords have a permanent asbestos insulation that stands up where other wires fail. The naturally heatproof asbestos insulation, impregnated with heat-, flame-, and moisture-resisting compounds, withstands conductor heating overloads. It won't bake brittle, dry out, flow, rot or crack under heat and resists oil, grease and corrosive fumes.

Get trouble-free long wire life in your circuits by installing Rockbestos A.V.C. 122 constructions give you a wide range of choice to meet specific requirements. When ordering or inquiring, please furnish CMP allotment number or symbol, and certification. For complete information and samples, write nearest branch office or:

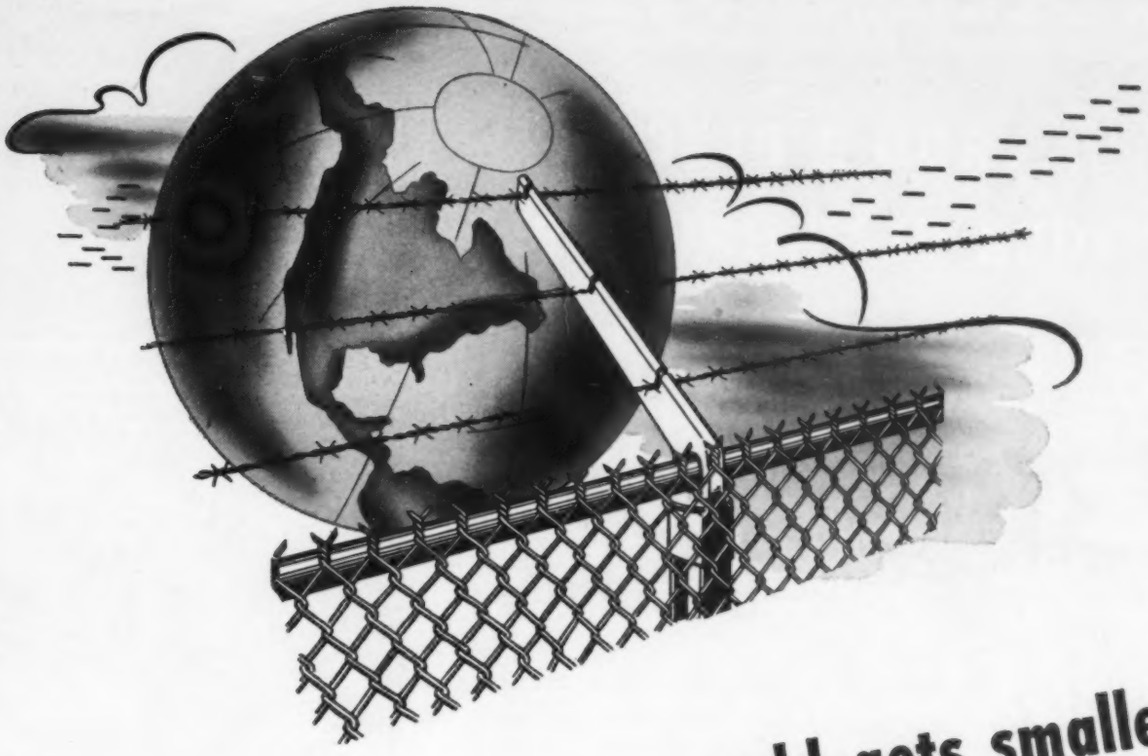
Rockbestos Products Corporation, 949 Nicoll St., New Haven 4, Conn.

FOR VICTORY—BUY WAR BONDS

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.



IT GROWS..as the world gets smaller

Thousands of miles of chain link fence surround and protect our industries — in war and peace. Here is a market for steel that will grow in length as the world gets smaller. Rod — for bars, bolts, rivets, chain link mesh and cable; Merchant Shapes — in T's, angles and channel forms; Skelp — for U-posts and tubing . . .

And as this market grows it will call for wire rod and merchant shapes in greater tonnage, in better quality, at lower costs.

. . . A call that you can answer profitably on new Morgan Rolling Mills.

MORGAN CONSTRUCTION COMPANY
Worcester
Massachusetts

R-124

PLAN NOW WITH **MORGAN**

ENGINEERS AND BUILDERS OF ROLLING MILLS . . . WIRE MILLS . . .
GAS PRODUCER MACHINES . . . REGENERATIVE FURNACE CONTROL

. . . ADD A PLACE AT YOUR PLANNING TABLE

FOR A *Reliance* MAN!

He can help machinery builders to put added sales appeal into that new machine.

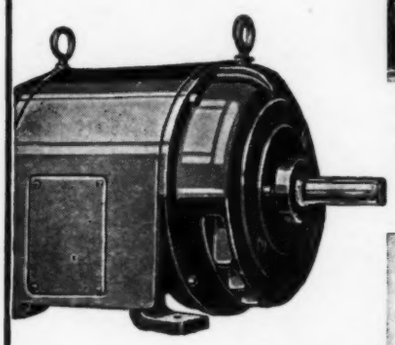
He can help manufacturing and processing plants to get the most from new production machinery or processing lines.

He can help by getting electric motor-drive into the picture early, where it properly and profitably belongs —so that design and planning begin with the question "What functions can the motor perform besides supplying power?" Reliance engineers in the industrial centers listed below can aid you in finding profitable answers.

Motor Drive Provides Within Itself a Means of

SPEED CONTROL • REVERSING
BRAKING • CONTROLLED ACCELERATION
TANDEM OPERATION • REMOTE CONTROL
TENSION CONTROL • SAFETY
SLOW SPEEDS (FOR INCHING, THREADING, INSPECTION)

Applying these functions to boost production and improve quality is APPLICATION ENGINEERING. That's our business.

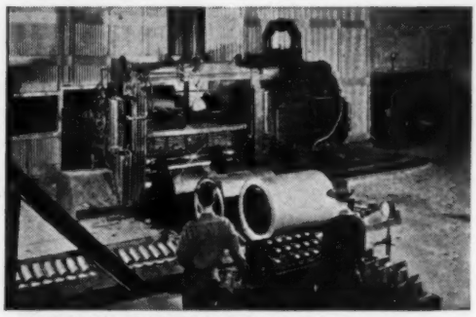


RELIANCE A-C D-C MOTORS

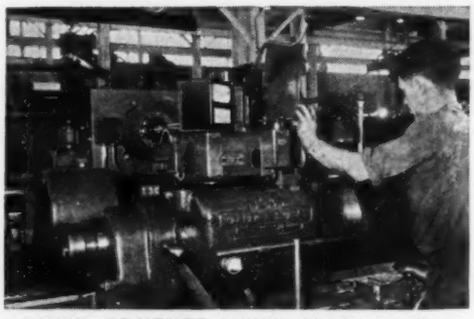
RELIANCE ELECTRIC & ENGINEERING CO.
1069 Ivanhoe Road • Cleveland 10, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S. C.) • Houston Los Angeles • Minneapolis • New York • Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis Salt Lake City • San Francisco • Syracuse • Washington, D. C. • and other principal cities

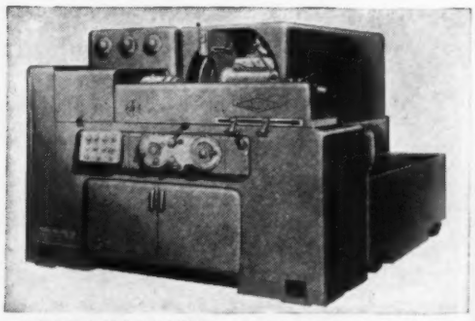
TENSION CONTROL (2569) Reliance Motor-drive for Tension Control is a good example of taking full advantage of characteristics inherent in the motor. It eliminates troublesome clutches . . . contributes substantially to the quality and uniformity of product which must be processed under tension.



TANDEM OPERATION (3124) The processing of materials in coil form is facilitated by the use of Reliance Tandem (or Range) Drive. Material moves faster with less handling . . . driving parts are simplified, space is saved. This is a subject of every-day consideration at Reliance.



SPEED CONTROL (4578) Nothing offers greater possibilities for the simplification of machine design than Reliance Adjustable-speed Drives. Available for both A-c. and D-c. Ease and convenience of control contribute to all-day, top-notch production.



STREAMLINING (3691) Used as a basis for streamlined design Reliance Motor-drive contributes to much more than beauty. Power is closer to where it is needed,—there are fewer mechanical "go-betweens". Control of starting, stopping, speed changing, reversing are centralized with other machine operations. The motor is made to do its complete job as a production aid.

Table roll bearings that do the Job

GATKE Table Roll Bearings are moulded to machined accuracy in the required shape and size for replacing metal bearings without change in standards.

A user reports, "First set of bearings still going good after nearly four years" on an application where they "couldn't keep metal bearings on the job."

Years of service without changing bearings or reconditioning journals!

That's GATKE Bearing performance on table roll applications where metal bearings had been replaced and journals reconditioned approximately 12 times a year.

Remember this — GATKE Bearings are moulded at pressures far greater than those applied in service. They withstand shocks and blows that "brinnel" roller bearings and distort bronze.

Install GATKE Bearings on your toughest service. You'll soon see they save you plenty of maintenance expense, relieve the machine shop of needless work, and eliminate a heap of trouble.

Just send prints for recommendation and quotation.

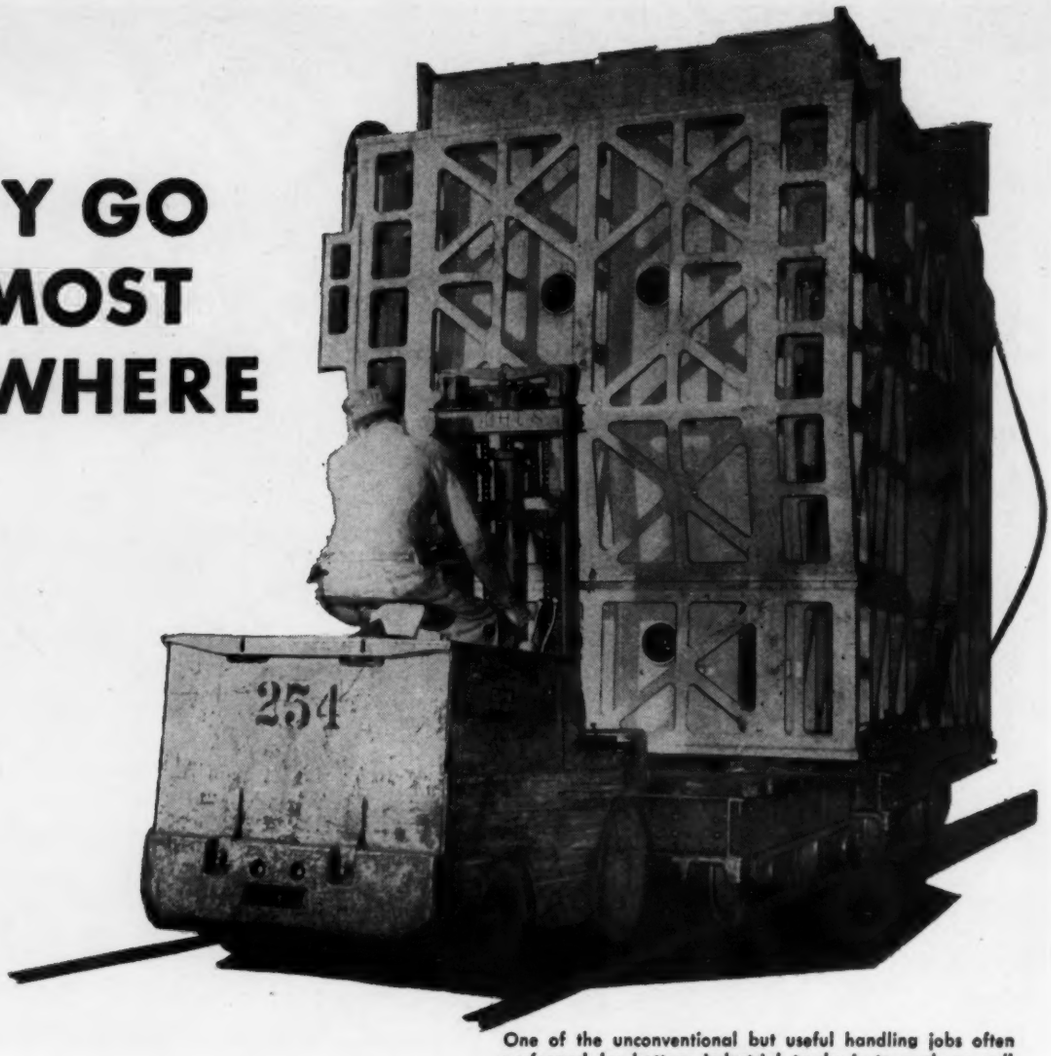
GATKE CORPORATION
228 N. La Salle St. Chicago 1, Ill.

Other **GATKE PRODUCTS**
Brake Lining
Clutch Facings
Friction Blocks
Silent Gears
Pump Valves
Piston Rings
Sheet Packings

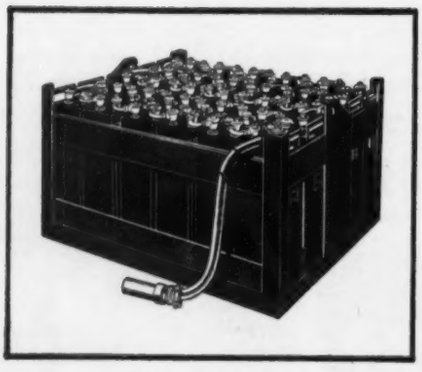
Gatke NON-METALLIC MOULDED FABRIC **Bearings**

For Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes, Acid Resisting Service, and Other Tough Jobs.

THEY GO ALMOST ANYWHERE



One of the unconventional but useful handling jobs often performed by battery industrial trucks is to push or pull heavy loads between craneways. Articles describing modern methods of material handling appear regularly in our STORAGE BATTERY POWER. Send for sample copy if you do not already receive it.



BECAUSE they are quiet and free from fumes, battery industrial trucks can be used without restriction in virtually any department of the plant. They can even be provided with spark-enclosed construction for operation in locations where fire and explosion hazards may exist.

They use low-cost electric power, and they use it with maximum economy, because they start instantly, yet consume no power during stops. With electric-motor drive for both traction and lifting, they have a minimum of wearing parts; are easy to maintain; are rarely out of service for repairs.

Thus, they are inherently dependable and economical, and this is especially important in the war industries where they are working 24 hours a day. Here they have the additional advantage of operating from one battery while another is on charge; except for the few minutes needed to exchange batteries, they need not stop for servicing of the power unit.

They are extra dependable and extra economical when Edison alkaline batteries are used. With steel cell construction, a solution which is a natural preservative of steel, and a fool-proof principle of operation, they are the longest-lived and most durable of all storage batteries. *Edison Storage Battery Division of Thomas A. Edison, Incorporated, West Orange, N. J.*

Edison
ALKALINE BATTERIES

Years ago motor and generator brushes had copper strips or wire bristles to conduct electricity from stationary to rotating parts—that's how they got their name. Carbon is now the material for all sizes of these brushes.

THEY HELP BRING THE GIANTS HOME

ONE OF the "little things" that are contributing greatly to the safety and welfare of our fighting men, is a special kind of carbon brush used in high-altitude planes. These brushes are essential to the generators and motors that supply energy for the radios, firing apparatus, gun turrets, bomb bay doors, landing gear, and other equipment of the planes. A heavy bomber has more than 40 of these devices requiring brushes.

Ordinary brushes disintegrate in a few minutes at altitudes where the air is "thin" and dry. A brush that would be dependable from take-off to ceiling and would have a life of 100 hours or more—had to be found. It came from the laboratories of NATIONAL CARBON COMPANY, INC., a Unit of UCC.

Carbon is useful in many other ways to Americans at war. Therapeutic lamps, which employ the carbon arc, are helping to restore health to sick and wounded men. Activated carbon in gas masks, by absorbing toxic vapors, is ready to save lives.

In the two-way radio telephone—the walkie-talkie and the handy-talkie—and in hearing aids for the deafened, carbon has another role. Carbon is essential in the small, powerful batteries that are used in these devices.

▼

Teachers, designers, and operators of electric motors, generators, and rotary converters are invited to send for "Modern Pyramids." This is a series of pamphlets containing practical suggestions on the performance, characteristics, operation, and application of carbon, graphite and metal-graphite brushes. Write National Carbon Co., Inc., Cleveland 1, Ohio, Dept. 20-G

★ BUY UNITED STATES WAR BONDS AND STAMPS ★

The trade-mark "National" distinguishes products of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

CARBON PRODUCTS DIVISION, Cleveland 1, Ohio UCC New York, Pittsburgh, Chicago, San Francisco

NATIONAL ROLLS

WARS IMPROVE METHODS

INDUSTRY, like man, must accommodate war. And during such periods, by reason of emergency pressure, methods are improved.

In the roll industry, the blending of alloys, more uniform casting and greater precision in finishing have improved to the end that the roll of only a few years ago could not endure long against the strain common to the present era.

The makers of NATIONAL ROLLS are meeting the problems presented by the emergency pressure, and with the steel industry at large, will be in excellent position to serve the post-war domestic and world demand for steel — a volume that may ultimately be even greater than current output.

The NATIONAL ROLL & FOUNDRY COMPANY

All Grades of Cast Rolls—Iron and Iron Alloy—Steel and Steel Alloy
Heavy Iron Castings and Rolling Mill Equipment

AVONMORE, PA.

OHIO

Extra Strength MAGNETS

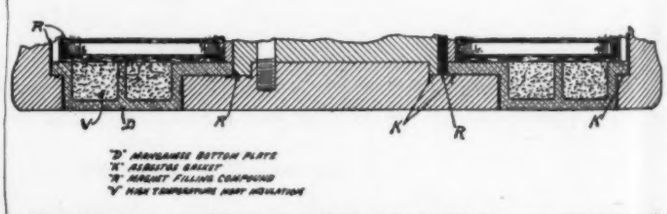
The OHIO 6 pancake coil magnets in the 55" and 65" diameters will average 35% better lifts than the standard magnets.

The OHIO 8 pancake coil magnets will average 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

Numerous repeat orders testify that performance equals or exceeds the statements above.

★When OHIO magnets are required to lift hot materials the heat resisting bottom construction shown below successfully retards the flow of heat from the load to the magnet coil and permits all day use.



Have you a problem requiring fast lifting or lifting of hot steel?

The OHIO Electric Mfg. Co.
5907 Bellford Avenue Cleveland 4, Ohio

Up where sawmills have to be flown in...

Bowser Engineered Fueling Systems

Installing airports and fueling systems on the route to Alaska operated by Northwest Airlines for the Army Air Forces, was a tough job. The route was largely through such primitive country that ground transportation was useless. For instance, a 24-bed hospital was flown in. So was a sawmill. That gives you an idea of the problems.

Bowser Aviation Fueling Systems were chosen for three major reasons . . .

1. In airport operations in many countries, working under all extremes of conditions, Bowser Systems have proved superior in the delivery of clean, dry, safe fuel.

2. Bowser designs and builds systems to meet virtually every special requirement.

3. Bowser-built equipment has established records for dependability and efficiency in hundreds of industries over scores of years.

Airport fueling systems are a specialized field, of course.

But they are no more specialized than steel mill lubrication systems. AND BOWSER EQUIPMENT IS STANDARD IN OVER 90% OF AMERICAN MILLS for the lubrication of mill stands, pinion gear sets, reduction gears, turbines, turbo blowers and pumps, as well as for coolant filtration and circulation, the filtration of air conditioning system solutions, the metering of fuel oil, etc.

Bowser engineers every steel mill installation as an integral part of the mill unit itself. That's a prime reason why Bowser dominates this field so completely.

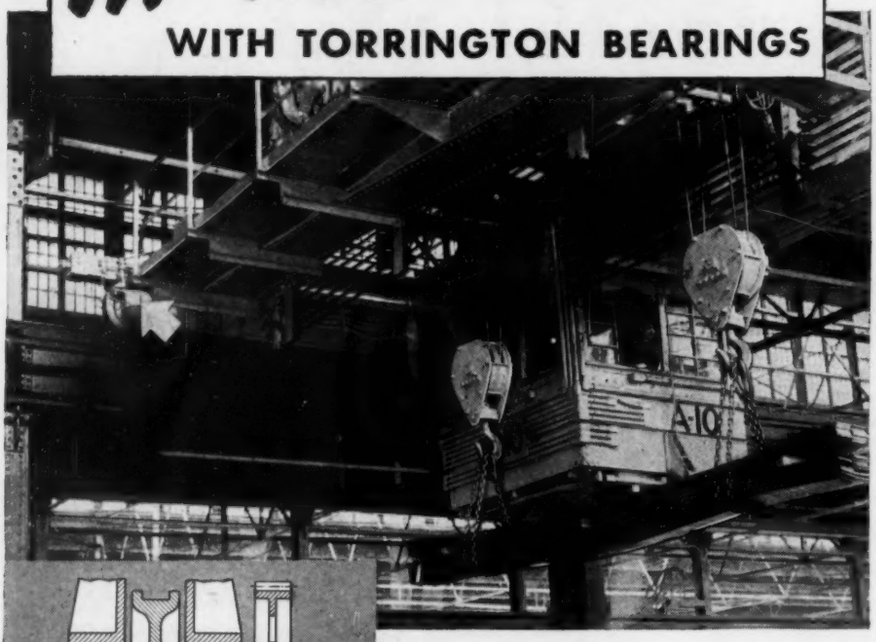
This is important, too—wherever the Bowser equipment is located, there's a complete Bowser service organization close by. BOWSER, INC., Fort Wayne 5, Indiana.

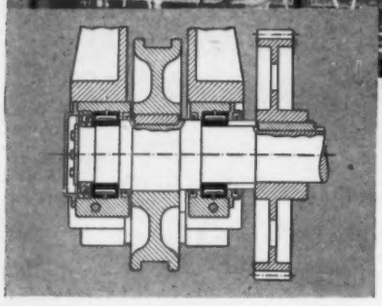
Not only has Bowser's war production earned the Army-Navy E... Bowser equipment has helped earn it for scores of other companies.

BOWSER ESTABLISHED 1885

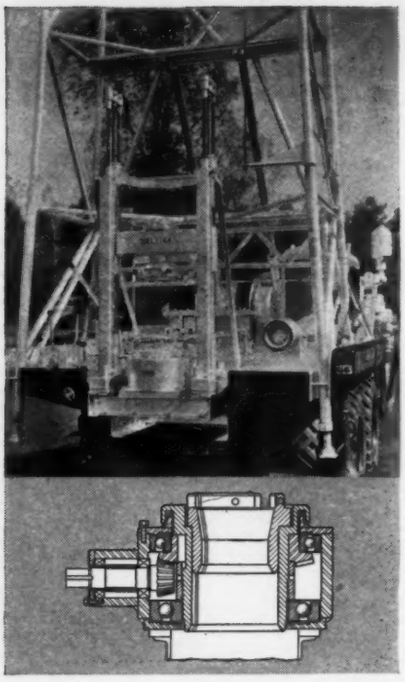
The Name That Means EXACT CONTROL of Liquids

IN THE NEWS
WITH TORRINGTON BEARINGS

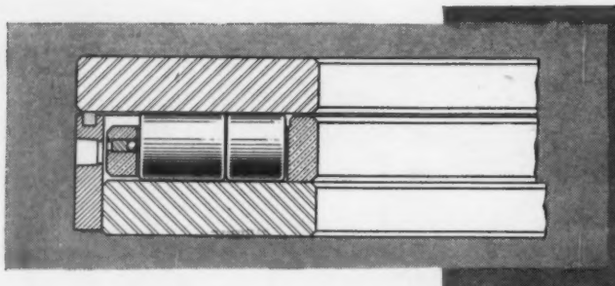


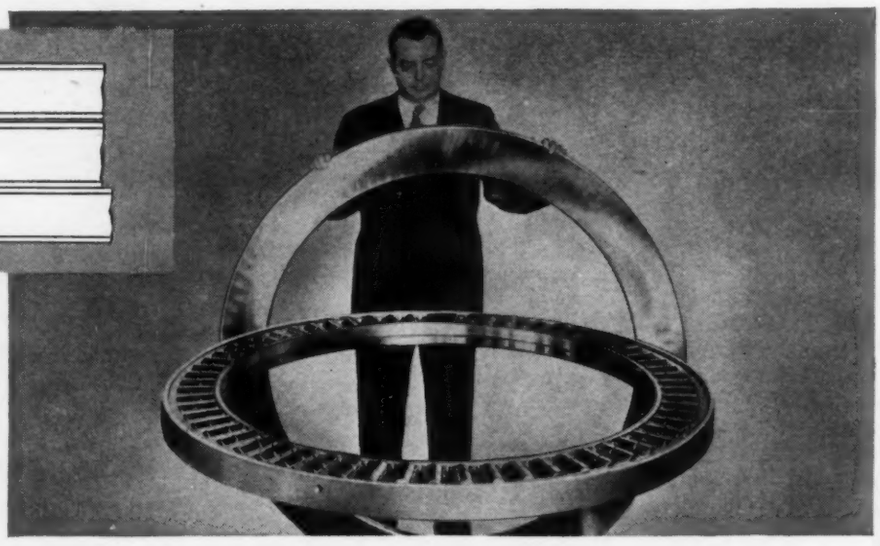


THE TREMENDOUS LOADS of this 15-ton overhead traveling crane in the Gary Steel Works of Carnegie-Illinois Steel Corporation are entrusted to bearings supplied by Torrington's Bantam Bearings Division. Two sets of Type NCS Heavy-Duty Needle Bearings, selected because of their high load capacity and compact design, are used in each axle housing, Torrington Ball Radial Bearings taking up the thrust load.



PLOTTING THE UNDERGROUND topography to determine where oil producing wells should be drilled is the important operation performed by this complete portable drilling unit manufactured by the Sullivan Machinery Company. To withstand the shocks, due to sudden changes in resistance as the drill bores through successive strata of soil, sand, water and solid rock, Torrington Ball Radial Bearings were selected for use in the rotary table assembly, as shown in the accompanying cross-section.





THIS HUGE ROLLER THRUST BEARING, measuring 53.125" O.D., is an example of Torrington engineering facilities for designing large bearings to carry extremely heavy loads. Its assembly includes 68 rollers 2" long and 1.5" in diameter; 68 rollers 1.375" long and 1.5" in diameter. The bearing is employed in the revolving mechanism of a large charging crane which serves the plate mill pre-heating furnace in one of the nation's major steel plants. Cross-section shows how felt packing was used to prevent entrance of scale and foreign matter during operation of the crane.

WHEN YOU SPECIFY Torrington Bearings, you have available specialized engineering service based on many years of experience with all types of bearing applications. Whether you need counsel on standard or custom-built bearings, TURN TO TORRINGTON.

ARMY E NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

Ball and Roller Bearing Makers Recommend NON-FLUID OIL...

BECAUSE — Their own tests proved conclusively that it is preferable to ordinary greases. NON-FLUID OIL is strictly neutral, so guarantees long life and dependable operation, by protecting bearings from pitting and corrosion.

You'll get bearing insurance from NON-FLUID OIL — and you'll save money — for NON-FLUID OIL outlasts ordinary greases 3 to 5 times.

Used successfully in leading iron and steel mills. Send for instructive bulletins.

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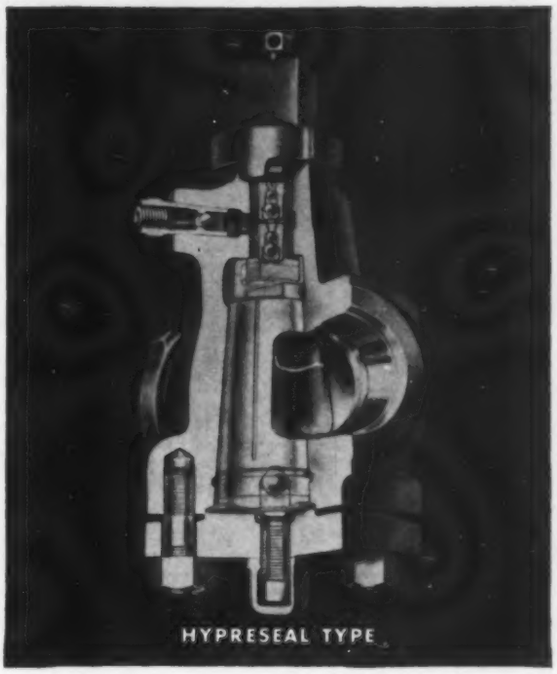
Modern Steel Mill Lubricant

Better Lubrication at Less Cost per Month

NORDSTROM Lubricated Valves



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Floating plug
No exposed seat
Plug seated on lubricant film
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Widely used in steel plants — on gas, chemical and oil lines — for positive control, regardless of pressure or temperature.

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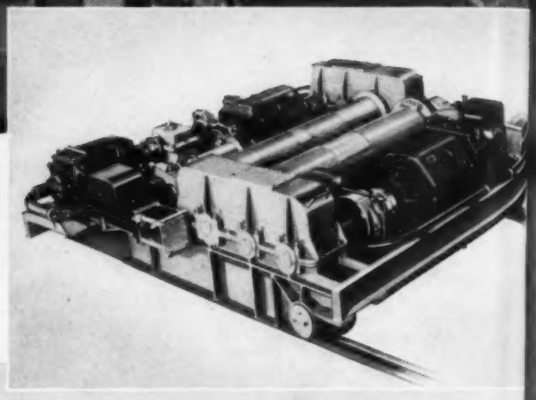


MORGAN 60-TON, 100'0" SPAN HEAVY-DUTY MILL TYPE CRANE

BUILT BY MORGAN *Engineering*

● Illustrated is one of two Morgan heavy-duty mill type cranes in a strip mill. Morgan superiority of design and construction is built into every part to insure many years of profitable service. They are equipped with fabricated welded trolleys and bridge trucks, hydraulic bridge brakes and anti-friction bearings throughout. Trolleys are of the gear box type using plain motors with flexible couplings. An auxiliary girder is provided for helping to support the cage, bridge motor and control units. Morgan engineers rely upon a highly skilled shop organization, modern equipment and progressive ideas in building heavy-duty mill type cranes.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO. Pittsburgh, 1420 Oliver Bldg.

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

INDEX TO ADVERTISERS

A

Aetna-Standard Engineering Company 1
Air Reduction Sales Company 12
American Hammered Piston Ring Division of Koppers Company 101
Amsler-Morton Company 29

B

Bantam Bearings Division, The Torrington Company 122
Bartlett-Hayward Division of Koppers Company 101
Birdsboro Steel Foundry and Machine Company 87
Blaw-Knox Company 20
Bloom Engineering Company 19
Bonnot Company 28
Bowser, Inc. 121
Bridgeport Safety Emery Wheel Company 22
Broden Construction Company ..... Cover 1

C

Clark Controller Company 109
Cleveland Crane and Engineering Company 30
Cleveland Worm and Gear Company 32
Continental Foundry and Machine Company 23
Crouse-Hinds Company 102
Cutler-Hammer, Inc. ..... Cover 2

D

De Laval Steam Turbine Company 107

E

Edison Storage Battery Division, Thomas A. Edison, Inc. 118
Electric Controller & Manufacturing Company 9
Electric Service Manufacturing Company 80
Electric Storage Battery Company 96
Engineering and Construction Division of Koppers Company 101

F

Farrel-Birmingham Company 7
Farval Corporation 88
Fitch Recuperator Company 14, 15
Flinn and Dreffin Company ..... Cover 1
Fluor Corporation, Ltd. 4, 5

G

Gas and Coke Division of Koppers Company 101
Gatke Corporation 117
General Electric Company ..... Cover 4

H

Hagan Corporation 86
Hallden Machine Company ..... Cover 1
Hays Corporation 103
Heppenstall Company 83
E. F. Houghton & Company 97
C. B. Hunt & Son 110
Hyatt Bearings Division, General Motors Corporation 81
Hydropress, Inc. 3

I

I-T-E Circuit Breaker Company ..... Cover 3

J

W. A. Jones Foundry and Machine Company 24

K

Koppers Coal Company 101
Koppers Company 101
Koppers Rheolaveur Company 101

L

Leeds & Northrup Company 11
Lewis Foundry and Machine Division, Blaw-Knox Company 26
Link-Belt Company 84
Loftus Engineering Corporation 72

M

Mackintosh-Hemphill Company 17
Maryland Drydock Company 101
Jas. H. Matthews and Company 106
McKay Machine Company ..... Cover 1
Merco-Nordstrom Valve Company 123
Mesta Machine Company 13
Morgan Construction Company 115
Morgan Engineering Company 126

N

National Bearing Metals Corporation 107
National Carbon Company, Inc., Carbon Products Division 119
National Roll and Foundry Company 120
New York and New Jersey Lubricant Company 123
Norma-Hoffmann Bearings Corporation 128
North American Manufacturing Company 104

O

Ohio Electric Manufacturing Company 120
Okonite Company 112

P

Pennsylvania Transformer Company 10
Philco Corporation, Storage Battery Division 92
Pittsburgh Lectromelt Furnace Corporation 34
Pittsburgh Rolls Division, Blaw-Knox Company 8
Poole Foundry and Machine Company 18
Post-Glover Electric Company 82

R

Reliance Electric and Engineering Company 116
Rockbestos Products Corporation 114
Rowan Controller Company 106, 107
Fred J. Ryan Company 79

S

Salem Engineering Company 16
Schloemann Engineering Corporation 94

T

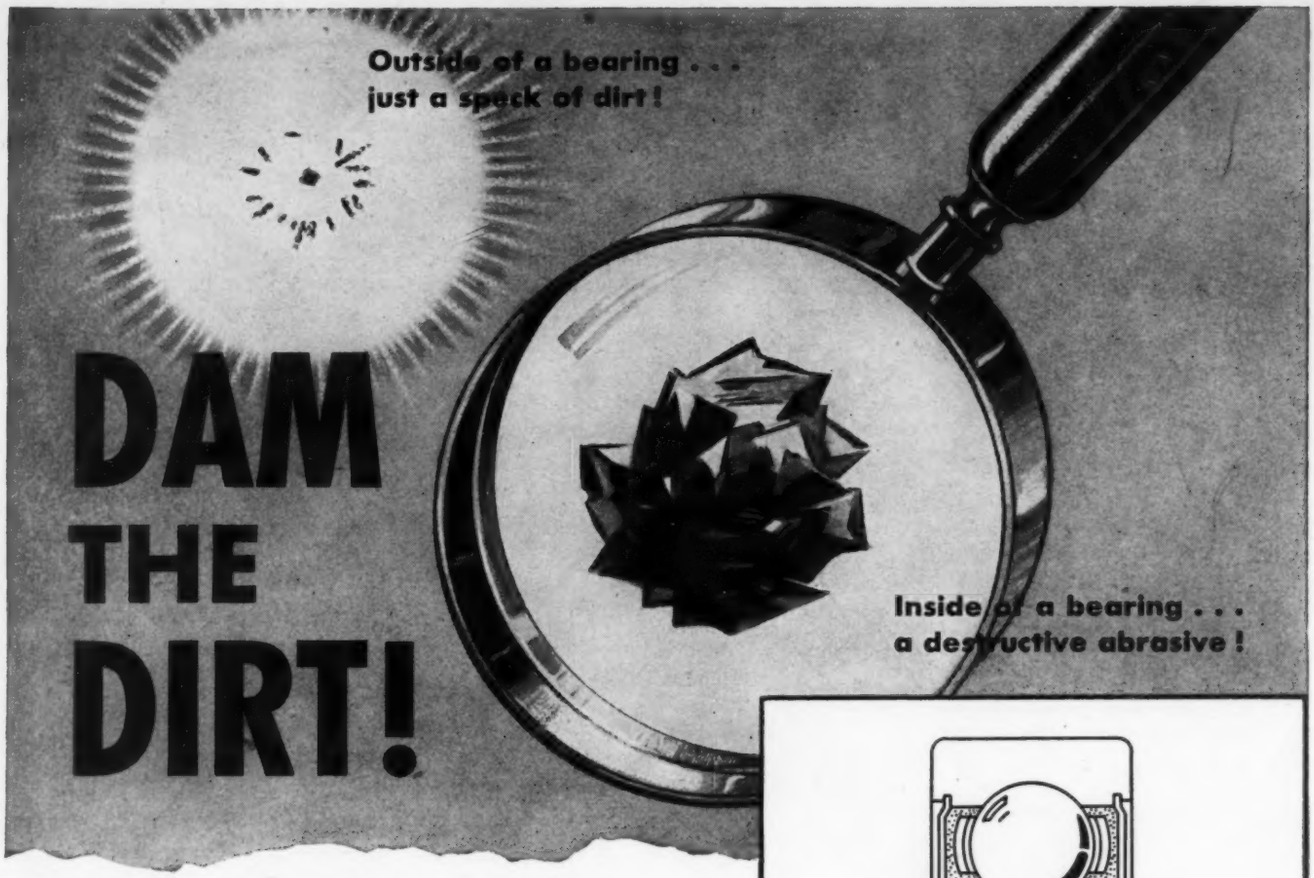
Tar and Chemical Division of Koppers Company 101
Thomas Flexible Coupling Company 90
Timken Roller Bearing Company 27
Tool Steel Gear & Pinion Company 25
The Torrington Company, Bantam Bearings Division 122
Trumbull Electric Manufacturing Company 113

U

Union Carbide and Carbon Corporation 119
United Engineering and Foundry Company 2, 6

W

Wagner Electric Corporation 21, 108
Wapakoneta Machine Company 93
Wean Engineering Company, Inc. ..... Cover 1
Wean Engineering Company of Canada, Ltd. ..... Cover 1
Wellman Smith Owens Engineering Corporation, Ltd. ..... Cover 1
Western Gas Division of Koppers Company 101
Westinghouse Electric and Manufacturing Company 85
White Tar Company of New Jersey, Inc. 101
Wood Preserving Corporation 101

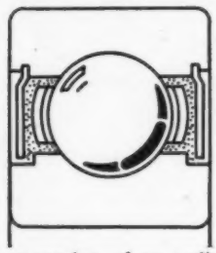


DAM THE DIRT!

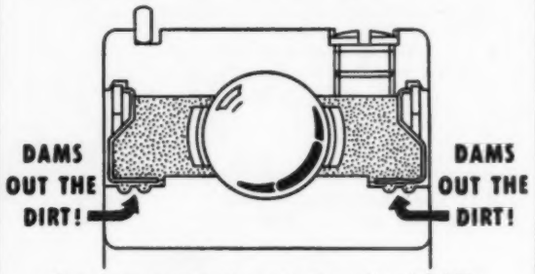
Dirt is the curse of every user of motors and machines. In shop and factory it gets into the average bearing, where it destroys the high finish, abrades the polished surfaces, creates friction that results in vibration, looseness and noise. And its action is cumulative—once started, it leads to premature bearing failure.

In the NORMA-HOFFMANN "CARTRIDGE" BALL BEARING, wearless metal seals combine with "labyrinth" grease grooves to form a highly effective barrier that dams out dirt—at the same time preventing the escape of the lubricant packed in the extra large grease reservoir afforded by the double-row width of the bearing. As a result, the initial high anti-friction efficiency of the "CARTRIDGE" BEARING is maintained over extremely long periods.

NOTE:—Many representative motor, machine and tool builders are incorporating the "CARTRIDGE" BEARING in their products. When you buy such units, ask for the NORMA-HOFFMANN "CARTRIDGE" BALL BEARING.



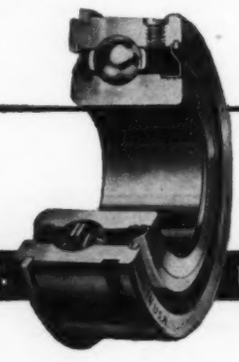
This shows a section of an ordinary single-row "shielded" ball bearing, with its space restrictions limiting the grease capacity and the effectiveness of the sealing devices.



Here, in contrast, note how the "CARTRIDGE" BEARING double-row width not only affords at least 100% larger grease capacity than the ordinary single-row "shielded" bearing, but also permits the use of a highly effective and wearless seal.

NORMA-HOFFMANN

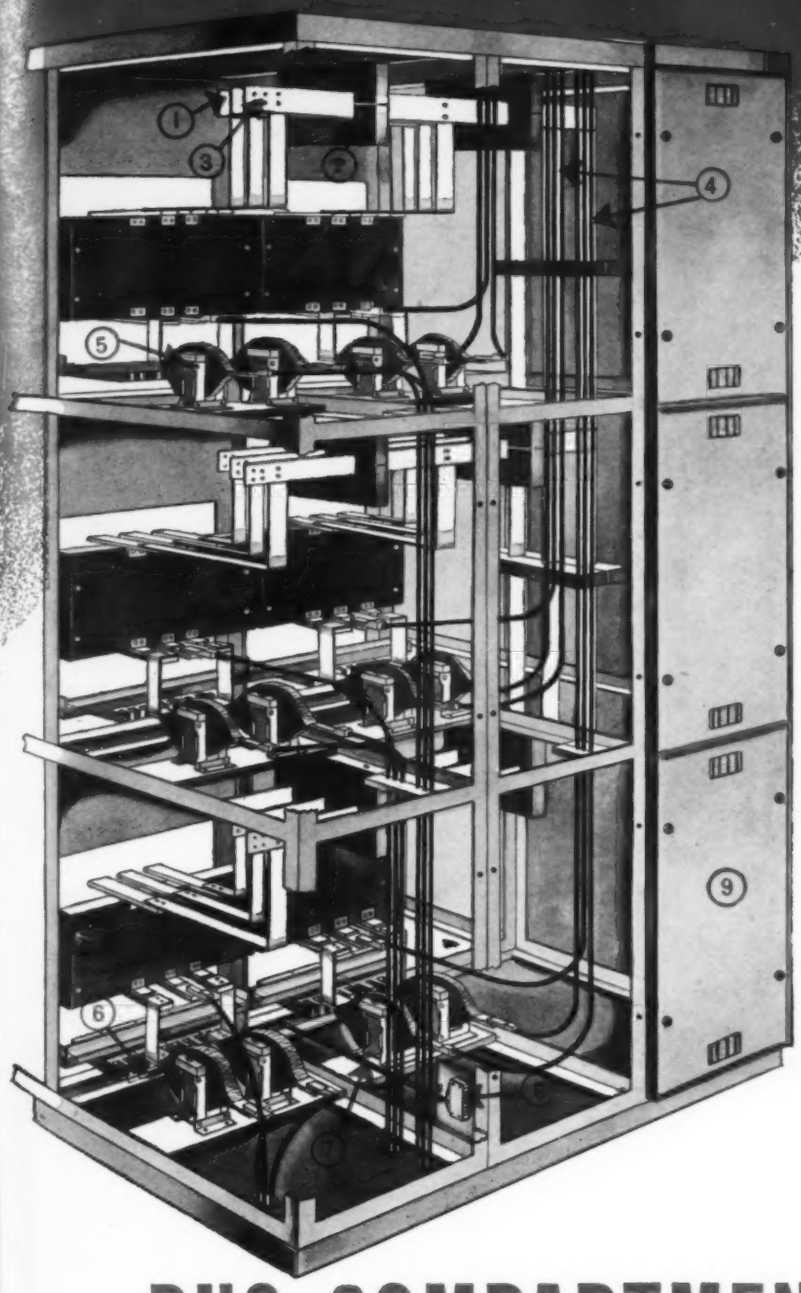
"CARTRIDGE"
BALL BEARING



NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONN. FOUNDED 1911

TO WIN THE WAR: WORK—FIGHT—BUY WAR SAVINGS BONDS!

(The cables in this illustration are shown small to give a clearer view of other details)



(1) **SILVER-PLATED BUSES**—All buses and connection bars are silver-plated, giving permanent freedom from overheating at the joints. Buses are drilled for future extensions. Tubular or channel buses may be used for heavy currents.

(2) **BUS SUPPORTS**—Blocks of insulating material impregnated with phenolic compound provide rigid support. Buses are braced for short circuit currents equal to interrupting rating of largest circuit breakers installed; minimum 25,000 amperes.

(3) **BOLTED JOINTS**—All joints are made with two or four bolts with lock washers for permanent tightness. Silver-plating assures low millivolt drop. Where required, spacers maintain sufficient clearance for adequate ventilation between bars.

(4) **PRIMARY CABLES**—May enter from floor or from overhead. Cable terminal connectors provided may be solder type or solderless clamp type, whichever purchaser prefers. Connector contact surfaces are silver-plated.

(5) **INSTRUMENT TRANSFORMERS**—Current transformers connected in primary circuits as shown. Contact surfaces are silver-plated. Purchaser may specify make desired. Accuracy and burden to suit requirements. Potential transformers also available.

(6) **SMALL WIRING**—No. 14 gauge (AWG) for control and protection circuits. Stranded, tinned, copper conductor insulated with synthetic rubber, flame-proof felted asbestos and cotton braid. Dependable material for this essential service.

(7) **WIRING CONDUITS**—Completely isolate control and signal circuit wires from primary conductors. Contribute an extra margin of safety with added security for operators and dependable operation of protective devices.

(8) **TERMINAL BLOCKS**—Eliminate splicing, soldering and taping of small wiring and practically exclude possibility of high resistance joints and open circuits. Marking strips identify each wire without time-consuming tracing.

(9) **REMOVABLE PANELS**—Completely enclose live parts; are readily removed for inspection. Flanged edges with welded corners make each panel stiff and free from warping. Bolts are attached and "lose-proof."

BUS COMPARTMENT DETAILS IN I-T-E STEEL-CLAD SWITCHGEAR

The details identified above represent standards of I-T-E design and construction. Such standards, however, should be noted in the light of an important, fundamental fact—that bus arrangements in switchgear enclosures are individual problems; that conditions of each installation are the guides. How deeply and thoroughly I-T-E examines the requirements of each job, can be gathered from a 24-page bulletin recently published, written by William Deans, Chief Engineer at I-T-E—"Electrical Buses and Bus Structures," Bulletin No. 4211. There have been more than 5000 requests for this bulletin; a few copies are available. For a point-by-point description of I-T-E drawout-type switchgear assemblies, including bus structures and compartment details, we have Bulletin 4207, which we will be pleased to send to you. Your request for a copy may be forwarded to the I-T-E representative nearest you or directly to I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

I-T-E

Representatives in Principal Cities

AIR SWITCHGEAR

ARMY E NAVY I-T-E

Want ½ CYCLE SHORT-CIRCUIT PROTECTION FOR YOUR MOTORS?

USE G-E LIMITAMP CONTROL

Equipped with EJ-2 Fuses
Contactors Good for Years of Constant, Repetitive Service

THIS control gives your motor the fast, positive short-circuit protection so necessary for safe operation on high voltages. Its interrupting capacity is more than adequate for installation on most industrial power circuits, and it can be used with squirrel cage, synchronous, and wound-rotor motors.

The current-limiting fuses, Type EJ-2, are an especially important feature. They operate in a split-cycle. When a short occurs, they cut off the rise in current in less than a quarter cycle, and clear it in less than a half cycle—long before the short has had time to harm the contactor or motor.

The full short never passes through the contactors in Limitamp controllers. Also, these contactors, which are air-break, are designed to meet the most severe requirements of high-voltage motor-control service. Mechanical life of several million operations, and contact-tip life twenty or more times the life of comparable oil-immersed tips, make these air-break contactors the logical answer for any severe duty—in steel mills, rubber mills, etc.

Here are 3 other important advantages

1. *Overload protection*—Isothermic overload relays protect the motor from overheating due to sustained overloads, locked rotor, or single-phasing.
2. *Personnel protection*—Totally metal-enclosed controllers give protection to operating personnel.
3. *Undervoltage protection*—All Limitamp controllers can be furnished with either instantaneous or time-delay undervoltage protection.

Need More Information?

You'll want to know all about this motor control. How the bus bars are enclosed for the operators' protection. How a group of these starters can be fitted together to give you a neat, compact control panel. Our local sales engineers will be glad to help you select a control to fit your application. *General Electric Company, Schenectady 5, N. Y.*

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Buy all the BONDS you can—and keep all you buy